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DEPARTMENT OF DEFENSE AND NAVY PERSONNEL SUPPLY MODELS: REPORT --ETC(U)

MAY 81 J A CIRIE, J J MILLER, H W SINAICO

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DEPARTMENT OF DEFENSE AND NAVY PERSONNEL SUPPLY MODELS

Edited by

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May 1981



Manpower Research and Advisory Services

This report was prepared under the Navy Manpower R&D Program of
the Office of Naval Research under Contract N00014-80-C-0438.

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|-------------------------------------|--|
| 1. REPORT NUMBER TR-9 | 2. GOVT ACCESSION NO. AD-A100177 | 3. RECIPIENT'S CATALOG NUMBER 2 |
| 4. TITLE (and Subtitle) Department of Defense and Navy Personnel Supply Models: Report of a Workshop | | 5. TYPE OF REPORT & PERIOD COVERED Technical Report |
| 7. AUTHOR(s) John A. Kirie James J. Miller H. Wallace Sinaiko | | 6. PERFORMING ORG. REPORT NUMBER TR-9 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Smithsonian Institution Washington, D.C. 20560 | | 8. CONTRACT OR GRANT NUMBER(s) N00014-80-C-0438 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research U.S. Department of the Navy Arlington, Virginia 22217 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62763N, RF 63-521-802 / NR 170-032 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12/91 | | 12. REPORT DATE May 81 |
| | | 13. NUMBER OF PAGES 87 |
| | | 15. SECURITY CLASS. (of this report) Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |
| 16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited. | | |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) | | |
| 18. SUPPLEMENTARY NOTES Supported by Office of Naval Research Manpower R&D Program. | | |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) military personnel supply comparison of forecasting models forecasting personnel supply multiple time series analysis budget allocation modeling unemployment and personnel supply recruitment advertising manpower modeling manpower resource planning dummy variables | | |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A workshop on personnel supply models was convened at the request of the Navy secretariat to evaluate several extant models. Formal critical reviews were presented by three academic consultants, and less formal papers were given by six researchers active in model development. Strengths and weaknesses of the models were elaborated and suggestions made for improving their usefulness to manpower policymakers. The main topics covered by the meeting were: | | |

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Block 20, continued:

modeling techniques, the uses of dummy variables, and data bases. Suggestions for further research were outlined.

The reviewers were:

Professor Frank M. Bass, Purdue University
Professor Robert M. Oliver, University of California, Berkeley
Professor N. Keith Womer, Clemson University

Other speakers were:

Mr. Vincent Carroll, University of Pennsylvania
Dr. Richard L. Fernandez, Rand Corporation
Dr. Lawrence Goldberg, Center for Naval Analyses
Professor Dominique M. Hanssens, University of California, Los Angeles
Professor Richard C. Morey, Duke University
Mr. Barry Siegel, Navy Personnel Research and Development Center

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Unclassified

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DEPARTMENT OF DEFENSE AND NAVY PERSONNEL SUPPLY MODELS

*Proceedings of a Workshop
held at
Arlington, Virginia*

January 22-23, 1981

EDITORS:

John A. Cirie
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Secretary of the Navy (Manpower)

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MAY 1981

This report was prepared under the Navy Manpower R&D Program of
the Office of Naval Research under Contract N00014-80-C-0438.

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ACKNOWLEDGMENTS

We are pleased to thank several people whose special contributions made the workshop a particularly timely and useful meeting. Ms. Mary Snavelly-Dixon, then Deputy Assistant Secretary of the Navy (Manpower), provided the initial idea and was an active participant, both during the planning phase and at the meeting. Dr. Thomas C. Varley, director of Operations Research Programs, Office of Naval Research, proposed the *modus operandi* and helped to identify the principal speakers. CDR Pieter Van Winkle, then director of the Research and Analysis Division, Navy Recruiting Command, served with the editors on the steering committee that put the meeting together. Ms. Becky Graham, administrative assistant, Manpower Research and Advisory Services, Smithsonian Institution, saw to it that everything was in the right place at the appointed time, and did the final production editing of this report.

John A. Cirie

James J. Miller

H. Wallace Sinaiko

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"Econometric modeling of Navy recruits appears to have promise. Although the models developed thus far are primitive and exploratory, they do show enough promise to warrant continued work. Good modeling work is often evolutionary in character."

Frank M. Bass

"The major goal of analysis is not to solve problems but to 'illuminate the problem.' Judged from this perspective all of the analyses have been successful in that each deepens our understanding of the recruiting problem."

Keith Womer

"While Navy faces serious shortfalls in the 1980's they can be met by increasing recruiting resources and military pay Navy must respond more quickly in dealing with temporary shortfalls."

Lawrence Goldberg

"Environmental variables, particularly wages, unemployment, and seasonality, have a stronger impact on recruiting than marketing variables . . . (and) recruiters have a stronger impact than advertising. Motivation of the recruiter force, however, is more important than the size of the recruiter force."

Dominique Hanssens

"Local advertising seems to be the most cost effective mechanism (marginal expenditure for an additional quality contract) with recruiters and magazines as second choices. Integration of the new local 'LEADS' data base into the enlistment equations will help resolve this matter."

Richard C. Morey

INTRODUCTION

Manning the Navy will be a crucial issue for the remainder of the 1980's. With a projected growth toward a 600-ship Navy during this decade, the availability of manpower resources becomes a central concern. The cornerstone of Navy's future manpower posture is its ability to recruit, from month to month and from year to year, the numbers and types of people required to support an effective and balanced force.

Today's Navy recruitment effort is focused on a declining market of 18- to 21-year old men and women who are simultaneously sought by each of the other Services. There is also increasing competition for this scarce resource from colleges and from industry. What part of this manpower market can Navy expect to recruit? What will the cost of that effort be—now and four years from now? What resource changes will be required in Navy's budgetary planning in order to ensure a continuous flow of qualified manpower into the fleet?

Rather than attempt to answer any of these questions specifically, the Workshop on Personnel Supply Models was convened to evaluate the current approaches and methods used in these forecasting processes and to chart new directions. Where are we now? How reliable are our tools? Where do we go from here? Those were the issues highlighted at the workshop.

This workshop was intended as a beginning in a process of collaboration among technicians (or modelers), theorists (or academicians), and users (or policymakers). It included three formal papers—critical reviews of the supply models by Professors Bass, Oliver, and Womer—and six less formal presentations by modelers.* The meeting was generally seen as a highly successful endeavor. It succeeded in providing a much needed exchange of perspectives and a deeper insight into the limitations as well as the potential uses of forecasting models. It was, as one commentator remarked, "a rare interface between practice and thought."

This report will provide both the outline and the details of what happened at the workshop. It is intended to serve the policymaker by providing a glimpse into the state of the art of forecasting and, in particular, into those models currently retained by Navy and the Office of the Secretary of Defense. It is not intended to form the basis for choosing one model over another.

We hope that this report will encourage future joint-service communication and collaboration in the area of supply forecasting and, specifically, in examining the effects of multi-service competition on personnel supply.

*The three formal papers, and abstracts of the modelers' remarks, form the main body of this report; the agenda for the workshop and a list of participants are appendices. The remarks by Mr. Vincent Carroll, Wharton Applied Research Center, the University of Pennsylvania, are not abstracted because of the highly tentative nature of the experimental findings he reported.

SUMMARY

Three models were used as a focus for the workshop: the CNA Model of High School Graduate Enlistments, developed by Dr. Lawrence Goldberg, Center for Naval Analyses, and hereinafter referred to as "the CNA model"; the Budget Allocation and Enlistment Prediction Model, developed by Professor Richard C. Morey, Duke University, and hereinafter referred to as "the Duke model"; and an enlisted supply forecasting model developed by Dr. Richard L. Fernandez, the Rand Corporation, and hereinafter referred to as "the Rand model." Each of these models is dynamic in that it has already undergone some evolution in methodology; there have been no fewer than five major modifications of both the Duke and CNA models. The three models are similar, however, in that each attempts to measure the impacts of various factors (economic, demographic, or policy variables) on the number of Navy enlistments. The CNA and Rand models are specifically designed to predict or forecast the numbers of potential Navy enlistments achievable over a future period given some set of conditions. The Duke model is also predictive, but it focuses on the process of resource allocation in the management of recruiting.

Although the main part of the discussion centered around these particular models, there was information, speculation, and some synthesis about forecasting and modeling in general. Following are the main conclusions that came out of the workshop:

- o Each of the models examined has weakness and, in its present state, should be used with caution by policymakers.

- o As better data are accumulated and as common definitions and scales are established and applied, these models should develop into useful tools for forecasting the effects of alternative policies.

- o The user of these or similar models must be aware of the effects of changes in the environment as well as anticipated policy changes; an example of the former is shifting rates of unemployment. The traditional use of econometric models implies that the future will be like the past. The Navy, however, is particularly interested in using econometric models which study the effects of new policies. Such models must therefore be continuously refined, tested, and updated.

- o The Duke model is the most complex of the three in that it attempts to provide a methodology for allocating recruiter and advertising resources. (The model has been adopted by the Navy Recruiting Command for that purpose.)

- o Both the CNA and Rand models have statistical deficiencies, and they differ conceptually in some respects. The CNA model considers manpower demand (quota) as well as supply. It attempts to study policy implications. (A later version of the model is considerably more accurate than earlier versions.) The CNA model also attempts to provide a sense of the relative importance of different variables by deriving elasticities. (An elasticity is the percentage change in supply caused by a one percentage change in a supply factor.)

- o Exogenous factors (i.e., those over which the Navy has no control, such as unemployment) have powerful effects on the availability of personnel. The effects of these factors are most difficult to estimate. The more "controllable" variables, i.e., recruiters and advertising resources, impact on accessions with greater predictability. For the most part, recruiters influence accessions more directly and more quickly than does advertising.

- o A very large experiment in which recruiting resources were systematically varied on a national scale is beginning to provide further insight into the recruiting process. (The work is hereinafter identified as "the Wharton experiment.") The preliminary findings generally agree with the econometric modeling results, indicating that all of the models reviewed are on the right track. Wharton results, for example, point to substantial recruiter effects and a somewhat lagged or dampened advertising effect on enlistments.

- o Extensive data bases have been developed by the modelers and should be shared within the community. These data bases, however, have not been compatible with one another—which suggests a need for the users of the models to become more knowledgeable and specific about the objectives of the forecasting process. For example, is it "high school graduate enlistment contracts" only, or "total enlistments" (personnel shipped plus those in the Delayed Entry Program), or "all accessions" that are to be measured?

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The following paragraphs set out in greater detail the main points made by the speakers at the meeting. There are a few contradictions—for example, concerning the relative values of advertising and recruiters; these contradictions are deliberately retained to show the absence of consensus on some issues. The material in this section is extracted from the written presentations of all the speakers, with the source of each item given.

Modeling Techniques

- o All supply models should include reasonable confidence bands. But this is not done by any of the models considered here: (a) the confidence interval for the Rand model decreases with time, which is not logical; (b) the Duke model includes no published confidence bounds; and (c) the CNA model shows an interval of ± 2000 , which is probably too small. (Oliver)

- o Models which use both cross-sectional and time series data make assumptions about the homogeneity of relationships. Such relationships should be tested before a decision is made to estimate supply by using pooled data. (Bass)

- o In modeling personnel supply to the Navy, "new contracts" is a more reasonable independent variable than "accessions" because the former deals directly with the point at which enlistment decisions are made; "new contracts" also eliminates lag effects introduced by the delayed entry pool. (Womer)

- o It may be useful to develop a model that projects the numbers of recruits who will survive basic training. (Womer)

- o Each of the models was evaluated by curve fitting methods; the use of forecast residuals (error terms) should also be considered. (Oliver)
(Editors' Note: Morey has, in fact, performed this type of analysis using a separate year of data; results for FY 79 yielded an error of 4%-7%.)

- o A model's forecasts may not be valid if recruiters and advertising budgets are allocated differently in practice than they are in the model's data base. (Womer)

- o To facilitate the comparison of different supply forecasting models there needs to be at least one dependent variable or output measure common to all the models; an example of such a measure would be "non-prior-service males, mental group I-IIIa, high school diploma graduates." (Oliver)

- o Where possible, dependent and independent regression variables should be scaled to the same order of magnitude; mixing of dimensioned raw data with dimensionless ratios or indices should be avoided. (Oliver)

- o Multi-collinearity is an acute problem. For example, the Navy Personnel Research and Development Center (NPRDC) model shows a very high correlation between number of recruiters and advertising expenditures. But because of the aggregated nature of some models it is not possible to estimate precisely the separate effects of recruiters and advertising. (Siegel)

- o Diverse criteria may be appropriate for judging the value of supply models, according to their intended use. When policy analysis is the aim, it is essential that the validity with which the model represents relationships among variables be established. If the purpose of a model is to forecast supply, usefulness tends to replace validity as the criterion. (Bass)

- o It is important to be aware of the potential for change in the environment, a fact that can greatly change the usefulness of a model. This caution is particularly true for econometric models which imply that the future will be similar to the past. (Bass)

Dummy Variables*

- o In using dummy variables it must be asked if the event had an effect and if the effect was discrete or continuous. There is little evidence to indicate that testing to answer these questions took place in the development

*A "dummy variable" is used to capture phenomena which impact on dependent variables but which cannot be quantified beyond whether or not they have occurred. For example, the existence or absence of a GI Bill, said to affect the supply of personnel to the military, is a dummy variable in some models. The use of dummies often increases the power of other independent variables.

of the Navy personnel supply models, particularly the Duke model. It would appear that the Rand model suffers from the omission of dummy variables and that the change in the GI Bill is not properly modeled by a dummy variable. (Bass)

- o The inclusion of dummy variables should be considered as a "last resort" in modeling; i.e., dummies should be used only if a phenomenon cannot be adequately described in a more conventional, quantifiable way. (Womer)

- o With regard to the use of dummy variables to measure the effects of such policy changes as the termination of GI Bill educational benefits, the only apparent alternative approach would be to construct a single time series variable measuring the value of educational benefits under both the GI Bill and its replacement. Such a procedure does not appear to be feasible. (Fernandez)

Data

- o Data bases used in analyses have often been compiled for purposes other than the analysis at hand. Rather, appropriate data bases should be developed for use over a long period of time. (Bass) (Editors' note: Some models used "accessions" as the dependent variable while others used "new contracts." The latter term refers to persons who have joined the Navy but not yet proceeded to recruit training, including enlistees in the delayed entry pool; "accessions" are those enlistees who have been "shipped" to active duty. It was generally agreed at the workshop that using "new contracts" in place of "accessions" as the forecasted variable would be preferred.)

- o The data used in the several models under consideration—CNA, Rand, and Duke—should be shared. (Womer)

- o The accuracies of each of the models should be tested by using a standard data set to forecast personnel accessions; forecasts should then be compared to actual accessions; data need not be based on the real world, i.e., there should be a constructed data set. (Oliver) (Editors' note: The Defense Manpower Data Center could serve as the repository for such data sets; the feasibility of integrating model data sets with the DOD's Recruit Market Network should be examined.)

Suggestions for Further Study

- o Model multiple time series analysis should be examined for its applicability to supply model specification. Cross-correlation analysis should be used to determine the existence of causal relationships. (Bass)

- o Unemployment is a key independent variable in supply models. Normally, overall general unemployment rates are used because they are reliable and easy to obtain; it may be useful, however, to use less aggregated data such as youth unemployment. (Womer)

- o It would be possible to design an experiment in which advertising levels and recruiting effort could be systematically varied from one recruiting district to another; such an exercise would provide evidence to permit one to estimate the validity of the supply models. (Bass) (Editors' note: A recent field experiment conducted by the Wharton Applied Research Center will probably serve this purpose. The experiment was nationwide in scope and involved the co-variation of advertising budgets and numbers of recruiters; dependent variables included the number of accessions by the Navy Recruiting Command.)

- o The Wharton experiment (see note above) will provide insight into the recruiting process. Preliminary findings generally agree with formal modeling results. Further analysis of the very large amount of data being collected should provide the Navy—and the other Services—with many rare insights into the recruiting markets in which we operate. (Hanssens)

- o It would be useful to survey high school graduates (some who have joined the Navy and some who have not) with respect to their attitudes about military service, the importance of pay, awareness of advertising, etc. (Bass) (Editors' note: Such a survey, the Youth Attitude Tracking Study, is under way under the auspices of the Office of the Secretary of Defense.)

- o The cost of keeping recruiters in the field needs to be defined more accurately. The method should consider associated costs, such as vehicles, special pay and allowances, and office rental, as well as salaries. (Oliver)

Speakers' Conclusions

- o There is no evidence of unfavorable effects on Navy recruiting from the efforts of the other Services; Army and Marine Corps do not reduce Navy enlistments, and Air Force recruiting appears to have a positive influence on Navy accessions. (Goldberg)

- o Competitive advertising among the Services may have a net positive effect on recruiting throughout the DoD; the issue is empirical and can only be resolved by testing. (Bass)

- o The main value of recruitment advertising lies in the leads it generates. Print media, especially direct mail, generate more leads than do electronic media. Leads generated by national advertising are not very important for enlistments. Advertising effects are asymmetric over time. (Hanssens)

- o The carryover or lag effects of advertising can be tested by any of several available methods, e.g., modern multiple time series analysis. In addressing lag effects it would be useful to use a variety of non-linear response functions. (Bass)

- o Local advertising seems to be the most cost-effective single recruiting mechanism, with recruiters and magazine advertising as the next best

choices. The proportion of advertising-related expenditures in a total recruiting budget should probably be in the range of 15%-20%. (Morey)

- o Advertising has a diminishing return as well as delayed effects; both phenomena have to be taken into account in modeling. (Womer)

- o Personnel supply elasticity calculations showed that unemployment, national advertising, and larger numbers of recruiters all increase enlistments; certain Federal youth programs, such as those under the Department of Labor's Employment and Training Administration, negatively affect the supply of Navy enlistments. (Goldberg)

- o The Navy can increase the supply of enlistments by increasing recruiters, national advertising, or military pay. The cost of recruiting a high school graduate is lowest for national advertising (although the different media vary in price). Compared to national advertising, the cost of using recruiters is about two times as much; and bonuses cost much more per additional recruit. (Goldberg)

- o Environmental variables (wages, unemployment, and seasonality) have a stronger impact on the supply of personnel than do marketing variables, e.g., advertising. It is important to recognize that different categories of recruits—high school graduates, women, etc.—are differentially sensitive to these variables. (Hanssens)

- o The Navy should develop ways to respond rapidly to temporary personnel shortfalls; adjustments to pay and recruiting offer two approaches. (Goldberg)

- o Recruiters have a more pronounced influence on enlistments than does advertising. The motivation of the recruiter force, however, is more important than sheer numbers. For example, the use of rigidly defined goals, i.e., numbers of accessions per month, can be counterproductive in that recruiters may "turn off" when they make goal; the use of a continuous production function, which will include enlistees placed in the delayed entry pool, is a much more effective motivator. (Hanssens)

- o The number of high quality personnel enlisted has been shown to be influenced by the goals imposed by the Navy Recruiting Command: when requirements for these scarce resources are high, recruiters work harder. (Goldberg)

- o The procedures used to apportion recruiting goals among the Navy's six recruiting areas are imprecise. In some cases this diminishes the productivity of recruiters who are working under circumstances where the supply of high quality recruits is greater than the goal. (Siegel)

- o Regression approaches are most appropriate for modeling the supply of quality recruits, since the latter are truly supply-limited. Any results from analyses involving a combination of quality and non-quality recruits are suspect because the non-quality recruits are demand-limited; hence, standard regression approaches are not appropriate. (Morey)

PRESENTATIONS

Analysis of Navy Personnel Supply Models

Frank M. Bass

Purdue University

Overview of Issues

A review of econometric models, regardless of the area of application, should encompass certain broad issues as well as the specific problems inherent in a particular case. These broader issues are of general importance and help provide a focus in addressing specific issues. General issues include such matters as the purpose of the analysis, model testing, measurement limitations, and philosophy of model construction.

Forecasting vs. Policy Analysis

In evaluating a model it is important to keep in mind the purpose of the modeling effort. When policy analysis is the purpose model validity is crucial. If forecasting is the purpose the central question is: does it work? It is well known that models which are causally incorrect or incomplete often work pretty well for forecasting purposes. On the other hand, the use of such models for policy purposes would very likely lead to serious error.

Time series models with important variables omitted may provide good forecasts. If the omitted variables are highly correlated with the included variables, much of the information contained by the omitted variables will be captured by the included variables as well and, from a forecasting viewpoint, there will not be great information loss. However, estimates of the effects of individual variables can be badly biased when the wrong model is employed, either because of omitted variables or for other reasons. Therefore, policy decisions based upon the wrong model run severe risk of error.

When policy analysis is the purpose of model development it is vital that the model be carefully examined and tested with respect to the validity with which it represents the relationships among variables. When forecasting is the purpose usefulness tends to replace validity as the criterion by which the model should be judged.

Estimation vs. Testing

In much of the econometric literature and in many empirical studies it is implicit that the model is true. This has naturally lead to emphasis on estimation as opposed to testing. One

often finds that great emphasis is given to methods of estimation: ordinary least squares, generalized least squares, maximum likelihood and the like. However, as indicated by Basmann (1965), "testing is logically prior to estimation." It serves no purpose and may be misleading to estimate the parameters of a model unless the empirical evidence is in good agreement with the logical implications of the model. In some cases models may be falsified or an attempt made at falsification by confronting the implications of the models with data.

In some instances, as for example, with simultaneous equation models, numerous logical implications may be derived from the basic premises of the model and these implications may be examined with respect to agreement with the empirical evidence. Clearly, there is no point in estimating the model when there is disagreement between the logical implications of the model and the empirical evidence. Models which utilize both cross-sectional and time series data necessarily involve assumptions about the homogeneity of relationships. Are the slopes the same for each cross section? Are the intercepts the same? What method is best employed in pooling data? These issues are testable, and, as indicated by Bass and Wittink (1975), should be tested before a decision is made to estimate with pooled data.

Measurement and Data Bases

It is often the case that the data base used in analysis has been collected for purposes other than the analysis. In this instance the analysis is constrained by data availability. Some variables may be used as proxies for other more preferred measures. Measurement imperfections and data limitations will have an influence on the quality of the analysis. Econometric modeling is often an evolutionary process with both models being improved and data upgraded in the evolution. Thought should be given, then, to the development of a data base which will be useful in the long run.

Modern Modeling Methods

Historically, econometric models have been specified on an a priori basis, and this is the case with each of the econometric models of Navy personnel supply. Both the direction of causality and the lag structure are specified on the basis of judgment. Recently, modeling methods have been developed to permit the data to speak to the issue of model specification. The purpose of modern multiple time series analysis is to determine the structure or form of the model on the basis of the empirical evidence. Interest in time series analysis was stimulated by Box and Jenkins (1970) and Nelson (1973) with their contributions to univariate time series

analysis. Building on Granger's (1969) definition of causality, Box, Haugh, and Pierce (Haugh 1976; Haugh and Box 1977; Pierce 1977; Pierce and Haugh 1977) have shown how causal models can be identified by using cross-correlation analysis and have developed various tests for detecting the presence of causality. Zellner and Palm (1974) have shown a connection between time series and econometric modeling and Wall (1976) has developed a full information maximum likelihood routine for the estimation of model forms.

Although, as indicated, none of the econometric models of personnel supply have employed modern time series methods for model specification, consideration should be given to these modern methods in future work.

Questions and Answers--Technical

Reviewers of the Navy personnel supply models were asked to address a number of technical and non-technical questions. In this section answers to those questions will be provided.

Dummy Variables

Dummy variables have been used in a variety of ways in econometric models. For example, they are often used to account for the effects of seasonality, for the effects of geographic variation when cross-sectional and time series data are pooled, and to account for the effect of discrete events such as the changing of GI Bill benefits.

Dummy variables are often appropriate and useful. The use of a dummy variable implies that the effects of an event are discrete. In those instances when the true effect is discrete it is appropriate to include the dummy variable and failure to do so could lead to serious bias. In deciding upon the use of a dummy variable two questions must be answered: (1) did the event have an effect and, if so (2) was the effect discrete or continuous? There are methods of testing to provide answers to these questions, although there is very little evidence in the Navy supply models to indicate that such testing took place. Notably absent from the Duke study which pooled cross sectional and time series data is a test of the appropriateness of this pooling. It is true that the model was estimated both with and without cross-sectional dummies, but no attempt was made to determine whether or not slopes as well as intercepts varied by cross section.

The CNA model uses dummy variables to represent seasonality, the change in GI Bill benefits, increased recruiting effort, and the ending of the draft. The final model actually

estimated by Rand includes only a single dummy variable for fiscal year 1978. In the CNA analysis all coefficients have the expected sign except for the coefficient representing the effects of a change in the GI Bill, and that coefficient is of questionable significance. It would appear, then, that the Rand model suffers from the omission of dummy variables and that the effect of the change in the GI bill is nil or not modeled properly by a dummy variable.

Advertising Effects

Two questions have been posed with respect to the effects of advertising. The first of these has to do with the nature of the response function. The second concerns the carryover effects of advertising and methods of modeling these effects.

Should the advertising response function have a linear or a non-linear form? Although there is no question but that theoretically the non-linear form is superior to the linear form, in practice the linear form is often employed. The statistical properties of estimates based on linearity are often more developed and understood than those based on non-linear forms. Furthermore, there is a question of which of the many possible non-linear forms to employ. In any case, the first question to be answered is whether the effects of advertising are significant or not. The linear assumption is often useful enough to answer this question. Assuming the question is answered affirmatively, it may then be useful to explore a variety of non-linear response functions.

The carryover effects of advertising are captured in the lag structure employed in the model. The CNA analysis employs a "capital stock" method. In fact, this method is very close to the Koyck distributed lag assumption. Methods of testing the distributed lag effect of advertising have been explored by Bass and Clarke (1972). In addition, the previously mentioned modern multiple time series analysis is useful in deducing the nature of the lag structure.

Competition

How should competition between the services be taken into account and is this competition a zero-sum game? The answer to the question lies in testing. It is an empirical question and it should be possible to provide an answer on the basis of statistical analysis.

In studies in the private sector it has often been found that competitive advertising stimulates the demand for the product class so that, although competitive in character, the net effect on each competitor is positive. The issue has to

do with market share versus total demand. If the effect on total demand is greater than the effect on share, then the net effect may very well be positive. It may very well be that competitive advertising and recruiting activities by the services have a net effect which is positive for each of them. The question is an empirical one, however, and can only be answered by testing.

Questions and Answers--Non-Technical

Model Uses by the Consumer

Supply models can be used by the consumer for forecasting or for the evaluation of policy alternatives. As indicated previously, if a model is used for forecasting purposes it should be evaluated on the basis of the quality of the forecasts it provides. On the other hand, when policy analysis is the purpose one should have confidence that the model represents and captures real world relationships.

Although "wrong" models may, under certain conditions, provide adequate forecasts, it is also possible for models to fail in both a forecasting and in a policy analysis mode. The CNA model and the Rand model fit the historical data equally well (measured by R^2) and yet they seem to imply very different forecasts. The Rand model, as finally estimated, includes only a "pay" variable, and an "unemployment" variable, and a "recruiting" variable. The CNA model, on the other hand, includes more variables and, importantly, includes a variable which serves as a proxy for quota, a demand factor not considered in the Rand model. Both the Rand model and the CNA model estimated for percentage of high school graduates show an indication of residuals which are rather highly correlated, a signal that the models may be seriously deficient. On the other hand, the CNA model when estimated for percentage in the upper mental groups does not indicate highly correlated residuals. On the whole the CNA model appears to be superior to the Rand model for forecasting purposes. It should be noted that both models require that the independent variables be forecast, or specified, in order to forecast. Thus forecast precision will depend not only on model precision, but also upon the adequacy of the specification of the independent variables.

Assuming one has confidence in the model, it may be used to evaluate policy alternatives. Assuming the model is correct and the estimates precise, there is the potential for evaluating the effects of policy options, both in absolute terms and relative to other policy options. Before using a model for policy purposes, however, it is important that the

model be carefully scrutinized with respect to both its logical and statistical properties. In the CNA study, for example, the advertising effect is imprecisely estimated. The imprecision is indicated statistically as well as by the logical implications of the estimate. The assumption that advertising spending is spread evenly through the year may be the cause of the imprecision. It should also be noted that the estimate of eleven percent depreciation per quarter for the effects of advertising seems to be much too small, especially when compared to estimates of advertising decay in econometric studies of products. According to the CNA study it takes four years for 83 percent of the effects of advertising to accrue. It is generally agreed, on the other hand, that for product advertising almost all of the effects of advertising are felt within a few months.

Although there is some indication that advertising does have a positive effect upon the supply of high school graduate recruits and upper mental group recruits, one should not have great confidence in the precision with which this effect is estimated.

Major Pitfalls in Model Interpretation

In addition to correctness and precision characteristics of models already mentioned, it is important for the user to be aware of the potential for change in the environment. Although, of necessity, econometric models are estimated on the basis of historical data, application of analysis is with respect to the future. Environments change and some changes are sudden and unexpected. Econometric models are often useful devices for planning purposes. However, the use of such models does imply that the future will be like the past. Needless to say, econometric models should be continuously refined, tested, and updated.

Complementary Analysis

What complementary analysis should the military consumer investigate in conjunction with the use of forecasting models? Surveys of high school graduate recruits and non-recruits with respect to attitudes toward the military, the importance of pay, awareness of advertising, recruiting, etc. may be of value. In the private sector many firms maintain "tracking studies" which continuously monitor consumer attitudes toward their product and competitive products, advertising awareness, and buying patterns.

Experiments with advertising and recruiting effort on a geographic basis have the potential to be very valuable. In principle, it would be possible to design an experiment in

which advertising levels and recruiting effort varied substantially from one region to another. In this way the experimental and econometric evidence could be used in an attempt to provide convergent validity.

Use of the previously mentioned multiple time series method for model specification might very well improve and enhance the econometric models previously developed. At the very least this methodology should be explored.

Significant Trends and Biases

The CNA study and the Rand study employ time series observations only, while the Duke study utilizes both cross sectional and time series observations. The Duke study is the most conceptually ambitious of the three. It attempts to model simultaneous causality. As far as practical application is concerned this portion of the Duke study seems to be of little value because of the complexity of the resulting simultaneous model. It should also be noted that the model has not been tested. In both simultaneous and single equation estimation the Duke study pools district data and time series data. The models have been estimated both with and without dummy variables for the districts. However, there has been no test for homogeneity (see Bass and Wittink (1975)). Hence the precision of the estimates in the Duke study should be viewed with skepticism. An attempt to validate the Duke model was made by using it to forecast 1978 data. The forecasts are good, but for reasons already discussed, this should not provide confidence in the model or the coefficients.

The CNA model appears to be conceptually superior to the Rand model in that it takes into account the demand (quota) influence upon supply as well as supply factors. Both conceptually and statistically the Rand model appears to be the weaker of the two.

Although the studies do provide some useful information, the policy implications should be viewed with caution. It is now clear that both cross sectional as well as time series data will be available for analysis. As data accumulates and improves there does appear to be a good prospect for developing improved models which will be useful for policy purposes as well as forecasting purposes. The three studies should be viewed as primitive and exploratory. The limited value of the studies should in no way discourage continued modeling effort. The studies do provide some useful information and they do provide encouragement about the possibility of building excellent models in the future. In the following section more detailed comparison of the models will be provided.

Model Comparisons

CNA

The basis model estimated by CNA is

$$H = E \sum_i a_i Z_i - bE^2 + cE + \epsilon$$

$$H/E = \sum_i a_i Z_i - bE + c + \epsilon/E,$$

where H = HSGs or MG 1-3U HSGs, E = chargeable enlistments and the Z_i are the following factors:

- Pay** = Four years' military pay divided by four years' civilian pay
- UNEMP** = Unemployment rate of white males, 16-19 years old
- POP** = 18-24-year-old civilian male population
- GIBL** = Dummy variable (equal to one for quarters starting in 1977, zero otherwise) measuring effects of declines in G.I. Bill benefits
- NAVPL** = Dummy variable (equal to one for quarters starting in 1975, zero otherwise) measuring effects of a Navy policy which increased recruiters' efforts toward enlisting HSGs
- AVF** = Dummy variable (equal to one for quarters starting in 1973, zero otherwise) measuring effects of the ending of the draft
- RECR** = Number of recruiters
- $X_t(\delta) = (1-\delta)^t$ for δ s between 5 and 25 percent
- $Y_t(\delta) = I_0(1-\delta)^{t-1} + I_1(1-\delta)^{t-2} + \dots + I_{t-1}$ where I_t is the advertising budget adjusted for inflation in t and δ s are between 5 and 25 percent
- Q_1 = Dummy variable (equal to one in first calendar quarter, zero otherwise) measuring seasonality of enlistments

- Q_2 = Dummy variable (equal to one in second calendar quarter, zero otherwise) measuring seasonality of enlistments
- Q_3 = Dummy variable (equal to one in the third calendar quarter, zero otherwise) measuring seasonality of enlistments
- c = Constant term
- ϵ = Error term.

The model was estimated on the basis of quarterly data from the third quarter of 1971 through the fourth quarter of 1977. The parameter estimates are shown in the following table.

CNA

REGRESSION FINDINGS

| Independent variables | % HSG | t | % MG 1-3U | t |
|-----------------------|-------------------|--------------------|-------------------|-------------------|
| Constant | -7.99 | -1.60 ^a | -3.62 | -0.90 |
| Pay | 0.655 | 1.29 | 0.120 | 0.28 |
| UNEMP | 0.0299 | 2.64 ^b | 0.0219 | 2.02 ^b |
| POP | 0.000515 | 1.63 ^a | 0.000217 | 0.84 |
| E | -0.0000108 | 2.94 ^c | -0.0000105 | 3.30 ^c |
| RECR | 0.000244 | 2.34 ^b | 0.000215 | 2.50 ^b |
| X(11) | 2.01 | 1.99 ^b | 1.18 | 1.44 ^a |
| Y(11) | 0.00000231 | 1.32 ^d | 0.000000852 | 0.58 ^d |
| GIBL | 0.0453 | 1.57 ^a | 0.00306 | 0.10 |
| NAVPL | 0.0972 | 1.68 ^a | 0.153 | 2.92 ^c |
| AVF | -0.0430 | -0.54 | 0.0273 | 0.38 |
| Q ₁ | -0.0307 | -1.26 | -0.0180 | -1.02 |
| Q ₂ | 0.0305 | 1.56 | -0.0144 | 0.10 |
| Q ₃ | 0.157 | 3.10 ^c | 0.105 | 2.52 ^b |
| \bar{R}^2 | 0.899 | N.A. | 0.905 | N.A. |
| F(13,11) | 17.4 ^c | N.A. | 18.6 ^c | N.A. |
| D-W | 2.63 | N.A. | 2.15 | N.A. |
| Rho | -0.469 | 2.65 ^b | -0.191 | -0.97 |

^aStatistically significant at ten percent level.

^bStatistically significant at five percent level.

^cStatistically significant at one percent level.

^dF-test of X(11) and Y(11) together indicates statistical significance at five percent level for HSGs and ten percent level for MG 1-3U HSGs.

The CNA model used chargeables (E) as a proxy for quota. It postulates that, other things being equal, there is a non-linear (positive) relationship between demand (quota) and high school graduate and upper mental group recruits. This assumption does have empirical support as shown in the CNA study.

The coefficients estimated for the CNA model all have the expected sign except for the coefficient for GI Bill and even this coefficient is of questionable significance. Although the model fits the data well, the precision of the estimates of individual variables, especially advertising, is not great. For the high school graduate equation, the residuals are significantly autocorrelated.

The CNA model may or may not provide good forecasts. The test will be its forecasting ability. Regardless of its forecasting properties, there are reasons for viewing the policy implications of the model with some caution.

Rand

The postulated Rand model is

$$E_t / \text{Pool}_t = a_0 + \sum_{i=1}^{11} a_i \text{MDUM}_{i,t} + b(\text{MP}_t / \text{CP}_t) + c \text{RECR}_t + \sum_{j=0}^{11} d_j U_{t-j} + \epsilon_t$$

where:

E_t = voluntary enlistments in period t;

Pool_t = weighted average of NPS male civilians aged 17 to 21 at time t, the weights being the proportions of total DoD enlistments of each age in the post-draft years; in thousands;

$\text{MDUM}_{i,t}$ = indicator variables for month 1 (January) through 11 (November), taking on the value 1 if period t falls on month i, and zero otherwise;

MP_t = average first year regular military compensation at time t for enlistees with less than two years of service;

CP_t = average weekly earnings in the total private economy at time t, seasonally adjusted;

RECR_t = number of production recruiters for the particular service at time t;

- U_t = unemployment rate for males, aged 16 to 19, at time t, seasonally adjusted;
- ϵ_t = random disturbance term at time t, assumed independent and identically distributed normal random variables with mean zero.

The model finally estimated by Rand (omitting the constant and seasonal terms) is, however, shown in the following table.

RAND
NAVY REGRESSION COEFFICIENTS

| Mental Category | Mean of Dependent Variable | Recr. | Pay | Unem. | FY78 Dummy | RHO | R ² |
|-----------------|----------------------------|------------------|-----------------|------------------|------------------|-------|----------------|
| I & II | 1.153 | | 19.28 (6.69) | 45.04 (14.00) | -286.6 (75.6) | .4358 | .8940 |
| I & II | 1.153 | | 14.61 (9.91) | 49.56 (21.78) | | .6366 | .8795 |
| IIIA | .631 | .1259 (.0628) | -.30 (7.60) | 29.12 (11.94) | | .6282 | .9187 |
| IIIB | .560 | .1235 (.0727) | 4.52 (8.82) | 27.83 (13.76) | | .6213 | .9136 |

The data used to estimate the Rand model were monthly from July 1970 to September 1978. The Rand study estimated using the Cochrane-Orcutt technique because of the autocorrelated residuals. Although this technique is probably superior, in this case, to ordinary least squares, the real issue is not estimation, but model specification. It is not unlikely that the autocorrelated residuals are the result of model misspecification. If the model is misspecified any estimation method will result in biased estimates. The Rand model appears to be conceptually and statistically inferior to the CNA model.

CNA and Rand Forecast Comparison

The CNA and Rand models have been used to develop forecasts for 1980 through 1984. The forecasts are shown below.

CNA AND RAND FORECASTS FOR THE NAVY OF NONPRIOR SERVICE ENLISTMENTS BY MALE HIGH SCHOOL DIPLOMA GRADUATES IN MENTAL GROUPS 1-3, FY 1980-84

| <u>Fiscal year</u> | <u>CNA</u> | | <u>RAND</u> | |
|------------------------|-----------------|--|-----------------------------|--------------------------------------|
| | <u>Forecast</u> | <u>Change from previous year^a</u> | <u>Forecast^b</u> | <u>Change from previous year</u> |
| 1980 | 54303 | +3580 | 46315 | -4408 |
| 1981 | 52301 | -2002 | 48913 | +2598 |
| 1982 | 50076 | -2225 | 48995 | + 82 |
| 1983 | 48240 | -1836 | 46946 | -2049 |
| 1984 | 46215 | -2025 | 43774 | -3172 |

^aIn FY 1979 the actual number of nonprior service enlistments by male high school diploma graduates in mental groups 1-3 was 50,723.

^bModerate unemployment scenario, [1] p. 22.

Although there were differences in the variables used to generate the forecasts and some differences in assumptions about the levels of the variables, most of the differences in the forecasts are probably attributable more to the inclusion of a demand factor in the CNA model than to any other cause.

Duke

The Duke model is estimated from monthly and district data. The time frame is from January 1976 through December 1978 and there are observations for 43 recruiting districts included in the analysis. The Duke analysis includes both simultaneous equation estimation and single equation estimation. The Duke analysis has failed to provide tests for the appropriateness of pooling the time series and cross-sectional data and hence the estimates are suspect. The following three tables summarize some of the Duke estimates.

ESTIMATES OF PARAMETERS FOR
PREDICTING NOIC LEADS FROM THE HETEROSCEDASTIC MODEL

| Variable | Coeff. Estimate and short run elasticity | Standard Error | t-Value | Long Run Elasticity |
|---|--|-------------------|---------|------------------------|
| 1) District propensity to enlist (based on responses to question- naires) | .4204 | .0111 | 37.795 | .779 |
| 2) Percent of Popula- tion in district that is Black | .0767 | .00433 | 17.727 | .137 |
| 3) Percent of district population within SMSA | .0843 | .00728 | 11.58 | .150 |
| 4) Relative pay (ratio of average first year military pay to civilian) | .0636 | .0151 | 4.208 | .113 |
| 5) Dollars of expenditures in 1967 dollars for TV/Radio/ bill-boards per labor force member for the General Enlisted General Program | .1921 | .0069 | 28.037 | .342 |
| 6) Dollars of expenditures in 1967 dollars for printed materials per labor force member for the General En- listed General Program (does not include LAMS or RAD materials) | .4895 | .0124 | 39.389 | .872 |
| 7) Dollars of expendi- tures in 1967 dollars for the GEF-Minority Program | .0388 | .00918 | 4.225 | .069 |
| 8) Dollars of expenditures in 1967 dollars for the Joint Military Advertising Program (JADOR) per labor force member | -.0467 | .0117 | -2.525 | -.083 |
| 9) One month National Lagged Leads per labor force member | .4388* | .0101 | 43.261 | NA |

*This implies that 95% of the total impact of advertising on
leads is felt within 3.64 months of the advertising.

COMPARISON OF ESTIMATES OF LONG TERM ELASTICITIES
FOR NOIC LEADS FROM DIFFERENT MODELS

| | Single Stage Heteroscedastic Model (without district dummies) | Single Stage OLS Model (without dis- trict dummies) | Simultaneous Model With District Dummies | Simultaneous Model Without District Dummies |
|---|--|--|---|--|
| 1) Propensity | .78* | .80* | .66* | .77* |
| 2) Percent Black in District | .14* | .12* | .18* | .20* |
| 3) Urban/Rural mix in District | .15* | .18* | .23* | .29* |
| 4) Relative Pay in District | .11* | .07* | .38* | .34* |
| 5) TV/Radio Expendi- tures from GEP- General Budget | .342* | .35* | .14 | negative and insignificant |
| 6) Printed Expenditures from GEP-General Program | .872* | .63* | 2.3* | 3.01* |
| 7) GEP-Minority Expen- ditures in District | .069* | positive & insignificant | negative & insignificant | negative & insignificant |
| 8) JADOR Expenditures in District | -.08 | negative & insignificant | -.16 | -.68* |
| 9) Number of High School Seniors in District | negative and insignificant | negative but insignificant | .31* | .36* |

*Denotes significance at the 5% level.

ESTIMATES OF ELASTICITIES FOR HSG CONTRACTS WITH LEADS
AS AN EXPLANATORY VARIABLE

| | Short Term Elasticity from Hetero- scedastic Model | Standard Error from Hetero- scedastic Model | t-Statistic from Hetero- scedastic Model | Estimated Long Term Elasticity from Hetero- scedastic Model | Estimated Long Term Elasticity from OLS Model |
|--|--|---|---|--|---|
| 1) Number of HS seniors | .231 | .019 | 12.079 | .245 | .192 |
| 2) NOIC Leads with a 2 period lag | .0091 | .0021 | 4.40 | .0096 | .020 |
| 3) Propensity | .631 | .022 | 28.567 | .667 | .47 |
| 4) Percent Urban | .183 | .0096 | 19.05 | .194 | .11 |
| 5) LAMS | .043 | .0058 | 7.34 | .046 | negative & insignificant |
| 6) Recruiters | .685 | .0145 | 47.249 | .726 | .55 |
| 7) General Unem- ployment Rate | .171 | .010 | 15.925 | .181 | .78 |
| 8) Relative Pay | .158 | .014 | 11.149 | .167 | .10 |
| 9) HSG Contracts lagged 1 month (Koyck term) | .057* | .0039 | 14.718 | NA | .25** |

*This implies 95% of impact of additional LAMS and
recruiters efforts are felt within 1.04 months.

**This implies that 95% of impact of additional LAMS and
recruiters efforts felt within 2.16 months.

Summary and Conclusions

Econometric modeling of Navy recruits appears to have promise. Although the models developed thus far are primitive and exploratory, they do show enough promise to warrant continued work. Good modeling work is often evolutionary in character.

Future modeling effort should focus upon testing of the model specifications. Multiple time series methods of model specification should be examined and tests of cross sectional and time series relationships should be accomplished.

References

- Basmann, R. L., "On the Application of the Identifiability Test Statistic in Predictive Testing of Explanatory Economic Models," The Indian Economic Journal, Vol. 13, No. 3 (1965), pp. 387-423.
- Bass, Frank M. and Wittink, Dick R., "Pooling Issues and Methods in Regression Analysis with Examples in Marketing Research," Journal of Marketing Research, Vol. 12, November, (1975), pp. 414-425.
- Bass, Frank M. and Clarke, Darral G. (1972), Testing Distributed Lag Models of Advertising Effect, 9, August, pp. 298-308.
- Box, George E. P. and Jenkins, Gwilym M. (1970, rev. ed. 1976) Time Series Analysis: Forecasting and Control, San Francisco: Holden-Day.
- Granger, C. W. J. (1969), "Investigating Causal Relationships by Econometric Models and Cross-Spectral Methods," Econometrica, 37, July, pp. 424-438.
- Haugh, Larry D. (1976), "Checking the Independence of Two Covariance Stationary Time Series: A Univariate Residual Cross-Correlation Approach," Journal of the American Statistical Association, 71, June, pp. 378-385.
- _____ and Box, E. P. (1977), "Identification of Dynamic Regression (Distributed Lag) Models Connecting Two Time Series," Journal of the American Statistical Association, 72, March, pp. 121-130.
- Nelson, Charles R., (1973), Applied Time Series Analysis, San Francisco: Holden-Day.
- Pierce, David (1977), "Relationships--and the Lack thereof--Between Economic Time Series, With Special Reference to Money and Interest Rates," Journal of the American Statistical Association, 72, March, pp. 11-22.
- _____ and Haugh, Larry D. (1977), "Causality in Temporal Systems, Characteristics and a Survey," Journal of Econometrics, 5, May, pp. 265-293.
- Sellner, Arnold, and Palm, Franz (1974), "Time Series Analysis and Simultaneous Equation Econometric Models," Journal of Econometrics, 2, May, pp. 17-54.
- Wall, Kent D. (1976), "FIML Estimation of Rational Distributed Lag Structural Form Models," Annals of Economic and Social Measurement, 5, January, pp. 53-63.

A CRITIQUE
OF
U.S. NAVY PERSONNEL SUPPLY FORECASTS
(BASED ON THE CNA, DUKE, AND RAND MODELS)

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1. INTRODUCTION

The purpose of this report is to compare three forecasting models which estimate the supply of Navy manpower. These models have been developed by authors at the Center for Naval Analysis, the Rand Corporation, and Duke University. Analysis and model documentation is provided in the reports by Fernandez [1979, 1980], Goldberg [October 1979, March 1980, April 1980, May 1980, December 1980], and Morey [1979, July 1980, Dec. 1980]. The models were designed in order to predict the effect of economic variables and policy decisions upon the enlistments of the United States Navy. The numerical forecasts have been used during the 1979-1980 period to predict U.S. Navy enlistments over the period 1981-1990. In making comparisons of the forecasting techniques and numerical predictions made by each group, it was helpful to reformulate each model in terms of a common notation. Thus it became possible to compare the differences in underlying assumptions and the data bases used by each group of authors. Since the mathematical structure of the forecasting models, the definitions of key variables, and the analysis of the cross-sectional and time series data differed with each author, it was not easy to make simple comparisons of results.

At this time the United States no longer depends on a draft or conscription to supply its military forces with new enlistments. Voluntary enlistments have effectively supplied the military services from January of 1973 to the present. In attempting to forecast future enlistments one must first deal with new behavioral patterns and attitudes by young people in the 16-20 year age group, who view the U.S. Navy as a possible career. There are, in addition, a large number of external variables influencing enlistments, some of which are controllable, others are not.

The control or decision variables include: active recruiting by a recruiting staff, advertising of the U.S. Navy as a career, the attractiveness of the U.S. Navy to different mental groups, and special one-time-only financial inducements for joining the U.S. Navy. The uncontrollable exogenous variables that appear to affect U.S. Navy enlistments probably include the size of the manpower pool in the 18-24 year age groups, general economic conditions in the United States, unemployment levels and military pay levels legislated by Congress for all services.

U.S. Navy accessions and enlistments are predicted to decrease dramatically in the period 1981-1990 unless there are overt policy changes by Congress, U.S. Navy recruiting efforts, and/or changes in competitive economic factors. All three reports consistently predict this trend. Even though their models and forecasts differ numerically in certain time periods, the overall conclusion is very similar: (1) the manpower pool is expected to decrease in the period 1980-1990; (2) the attractiveness of the U.S. Navy as an employment career for high mental groups has decreased in the period

1970-1978, even while the eligible pool of manpower was increasing slightly; (3) the accessions in the upper mental groups is decreasing; and (4) the combination of the behavioral patterns in (2) with the decreasing supply pool forecast suggests a dramatic and serious shortage of high-quality accessions and enlistments during 1981-1990. Accessions are affected to a greater or lesser degree by unemployment levels, competitive salaries, announced manpower goals, etc., thus any uncertainties in forecasting the latter should also affect our enrollment forecasts and our confidence in these forecasts.

At a meeting organized by the Office of Naval Research in Washington, D.C. on January 22 and 23, 1981 several speakers brought attention to the fact that accurate forecasts of accessions were not, *per se*, of much interest or use in budget and force planning. Rather, it was argued, a good understanding of the relationships between and sensitivity of accessions to control or policy variables leads one directly to better recruiting and personnel management policies. However, it should be pointed out that if one is to choose between several proposed mathematical models, each one purporting to be an accurate description of the real world, it is first necessary to determine, within the limits of experimental error, how each model makes predictions when policy variables are known. In other words, can the model be trusted? Unless model forecasts give good fits to historical data they should not be trusted in predicting the result of new policies on future accessions.

Forecasts can be used in several distinct ways:

- (i) to analyze and explain descriptive models of historic events, with or without policy implications.
- (ii) to test models (to be used in the future) which predict historical events had the same models existed and been used as events unfolded in real time.
- (iii) to simulate alternative future policy scenarios.

2. FORECAST ERRORS vs CURVE-FITTING RESIDUALS

Suppose that at time t we have accumulated data on accessions, manpower pools, advertising budgets and other variables that influence accessions. We want to forecast future accessions in time period $t+k$ by using a mathematical relationship of the form

$$A_t = f(P_t, Q_t, R_t, S_t, U_t, \dots) \quad (1)$$

A_t = accessions in time period t

P_t = supply pool in time period t

Q_t = advertising budget in time period t

R_t = number of recruiters in time period t

S_t = salary (or relative salary) levels

U_t = unemployment level in time period t .

Some of these variables are random, some are policy or control variables, some are

measurable and others are not. As a first step we obtain the conditional expectations made at time t for a future time period $t+k$

$$f_{t,k} = E \left[A_{t+k} \begin{vmatrix} A_t, A_{t-1}, A_{t-2}, \dots \\ P_t, P_{t-1}, P_{t-2}, \dots \\ Q_t, Q_{t-1}, Q_{t-2}, \dots \\ \vdots \\ \vdots \\ \vdots \end{vmatrix} \right], \quad k \geq 1 \quad (2a)$$

and,

$$v_{t,k} = Var \left[A_{t+k} \begin{vmatrix} A_t, A_{t-1}, \dots \\ P_t, P_{t-1}, \dots \\ Q_t, Q_{t-1}, \dots \\ \vdots \\ \vdots \\ \vdots \end{vmatrix} \right], \quad (2b)$$

given *historical* data on accessions, recruiters, manpower pools and other variables that are found useful in the prediction of future accessions.

One of the more important measures of the goodness-of-fit of a forecasting model must be an analysis of the forecast residuals

$$e_{t+1} \text{ mark} = A_{t+1} - f_{t,1} \quad (3)$$

over as many time periods as the data and computations allow. The forecast residuals in (3) should be carefully distinguished from curve-fitting residuals

$$\epsilon_{t,-k} = A_{t-k} - f_{t,-k} \quad k \geq 1 \quad (4)$$

which are often used in regression analyses to test how well a proposed model fits past data. Note that in (4) one is using data at time t to "forecast" accessions at an earlier time!! In reality these are estimates of historical quantities, not forecasts made as they should and would have been made in real time. A legitimate forecast of A_{t-k} (as distinguished from a backward-looking estimate) based on data up to and including time $t-k-1$ would be

$$f_{t-k-1,1} = E \left[A_{t-k} \begin{vmatrix} A_{t-k-1}, A_{t-k-2}, \dots \\ P_{t-k-1}, P_{t-k-2}, \dots \\ Q_{t-k-1}, Q_{t-k-2}, \dots \\ \vdots \\ \vdots \\ \vdots \end{vmatrix} \right] \quad (5)$$

and the forecast residual would be $e_{t-k} = A_{t-k} - f_{t-k-1,1}$, not $\epsilon_{t,-k}$ in (4). The sum of squared residuals obtained from (3) are much larger than those obtained from (4). Thus, authors who provide measures of the goodness-of-fit of their forecasting models through summary statistics based on (4) significantly underestimate the true forecast errors of their models and usually come to the false conclusion that their model accurately "forecasts" the future and can therefore be trusted in simulating the effect of new policy variables.

In the simulation of future scenarios it is often necessary to assume that some subset of the variables will be given. As a result one may be faced with the problem of obtaining conditional forecasts where the future unrealized variables are assumed given. For example, if the effect of a particular unemployment scenario in conjunction with a given recruiting policy is being studied, the forecasting problem can be restated mathematically as

$$f_{t,k} = E \left[A_{t+k} \begin{vmatrix} A_t, & A_{t-1}, & \dots \\ P_t, & P_{t-1}, & \dots \\ R_{t+k}, & R_{t+k-1}, & \dots \\ U_{t+k}, & U_{t+k-1}, & \dots \end{vmatrix} \right] \quad (6)$$

with a similar conditional statement for the variance $v_{t,k}$. Equation (6) is very different from (2a) where no condition is placed on the future values of recruiters R_t and unemployment U_t , and one needs no forecast of $(R_{t+1}, R_{t+2}, \dots R_{t+k})$ or $(U_{t+1}, U_{t+2}, \dots U_{t+k})$. In other words it is important that the model designer, the analyst, and the user of models be alert to the varied conditions and assumptions on policy variables, i.e. whether they are assumed given or whether they, too, are included in the forecasting problem.

In principle the forecasting models should be tested for goodness-of-fit on a data base that is independent of the data base used to estimate parameters or suggest model identifications. It was not possible for the authors of the CNA, Duke, and Rand supply models to test their models in this fashion as the time periods for which data was available were severely limited. However, in reviewing the written reports of the supply models it was very disappointing to find that no attempt was made to distinguish between forecast errors and curve-fitting residuals. With the exception of the Rand reports no information was available on future confidence limits or the range of values in which accessions might lie. Even in the Rand reports the standard errors refer to estimation errors due to historical data, not forecast errors derived from (2) or (6).

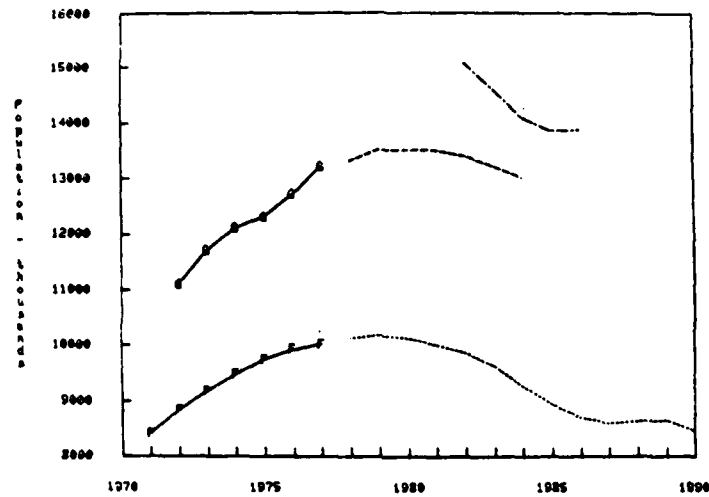
3. COMPARISONS OF THE DUKE, CNA, AND RAND MODELS

In reviewing and comparing the forecasts made by Fernandez (Rand Corporation), Goldberg (CNA), and Morey (Duke University) one must first attempt to find where differences occur.

- (1) do the authors attempt to forecast the same enlistment or accession cohorts?
- (2) do the authors use the same models?
- (3) do the authors define and use the same independent and exogenous variables?
- (4) do the authors use the same data?
- (5) do the authors use the same estimation techniques?
- (6) do the forecasts include confidence limits?

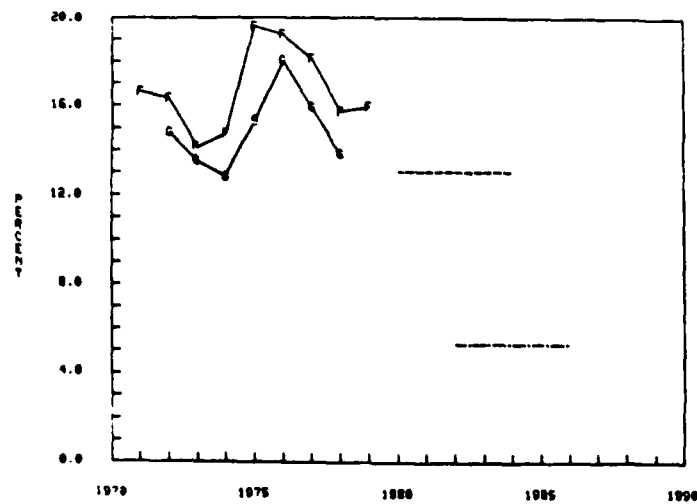
Historical and forecast values for the population pool (P_t) and unemployment levels (U_t) are given in Figures 1 and 2 respectively. The data or forecasts used by

FIG. 1: POPULATION POOL (in thousands)



ACTUAL: FERNANDEZ--solid line (F) GOLDBERG--solid line (G) MOREY--solid line (F)
FORECASTS: FERNANDEZ--dotted line GOLDBERG--dashed line MOREY--dot-dashed line

FIG. 2: UNEMPLOYMENT, 16-19 YEAR OLDS



ACTUAL: FERNANDEZ AND MOREY--solid line (F) GOLDBERG--solid (G)
FORECASTS: GOLDBERG--dashed line MOREY--dot-dashed line

each author are indicated in the legend of each figure. For future reference we should also mention that solid lines refer to historical observations while dashed or dotted lines refer to forecasts.

To make model comparisons we now need to look at the mathematical structure of the proposed models. In Fernandez [1979] the author uses a functional form which, except for seasonal indices and specific assumptions about dummy variables, is

$$\phi_t = A_t/P_t = K + bS_t + cR_t + \sum_j d_j U_{t-j} + \epsilon_t. \quad (1)$$

The constants b , c , and d_j are estimated from regressions on historical data. For purposes of future reference I would like to think of $\phi_t = A_t/P_t$ as the "attractiveness" coefficient of the U.S. Navy. It measures the fraction of a given population that enlists. It is noteworthy that only unemployment levels are selected as candidates when considering time lags, i.e., no lagged effects of recruiters or manpower pools are included. For future reference we should also note that this model can also be rewritten in the form

$$A_t = \phi_t P_t + \delta_t \quad (2)$$

where $\phi_t = \phi(R_t, S_t, U_t \dots)$ is linear in the indicated variables and δ_t is an error term. Although the author does not explicitly specify the distribution of ϵ_t , it is clear that for given P_t normality in ϵ_t translates into normality for A_t .

Forecasts of expected accessions in a future time period are then given by

$$\begin{aligned} E[A_{t+k}] &= P_{t+k} E[\phi_{t+k}] & k \geq 1 \\ \text{Var}[A_{t+k}] &= P_{t+k}^2 \text{Var}[\phi_{t+k}] \end{aligned} \quad (3)$$

assuming that there is no significant uncertainty in P_{t+k} . It is important to note that the lagged unemployment term contained in future ϕ_{t+k} has both realized and unrealized terms, i.e. the typical term contains a finite sum which can be decomposed as follows:

$$\begin{aligned} \sum_{j \geq 0} d_j U_{t+k-j} &= (d_0 U_{t+k} + d_1 U_{t+k-1} + \dots + d_{k-1} U_{t+1}) \\ &+ (d_k U_t + d_{k+1} U_{t-1} + \dots). \end{aligned} \quad (4)$$

The terms in the first parentheses are unrealized at time t and contribute to the uncertainty in future A_{t+k} , whereas the terms in the second parentheses have already occurred and do not contribute to the uncertainty. Thus as a separate problem one may have to find suitable predictors for unemployment, such as

$$E[U_{t+k} \mid U_t, U_{t-1}, \dots] \quad (5a)$$

$$\text{Var}[U_{t+k} \mid U_t, U_{t-1}, \dots] \quad (5b)$$

Although Fernandez does not explicitly state how unemployment levels should be predicted, it is this reviewer's experience that the well-known exponential smoothing model based on a correlated random walk

$$U_{t+1} = U_t + \epsilon_{t+1} - \theta \epsilon_t \quad 0 < \theta < 1 \quad (5c)$$

is close to being an optimal least-squares predictor of such economic time-series (see, for example, the book by Granger and Newbold [1977] and recent papers by Chazen [1977] and Eckstein [1979]). With such a model the predictor of expected future employment levels for *all* future k would be given by

$$E[U_{t+k} | U_t, U_{t-1}, \dots] = (1-\theta) \sum_{j=0}^{\infty} \theta^j U_{t-j} \quad (5d)$$

In Fernandez [1980] the author supplies us with regressions and revised forecasts based on new data and a slightly different model formulated in terms of the logarithms of the accession rate, i.e.

$$A_t/P_t = K S_t^b R_t^c U_{t-2}^d e^{\epsilon_t} \quad (6a)$$

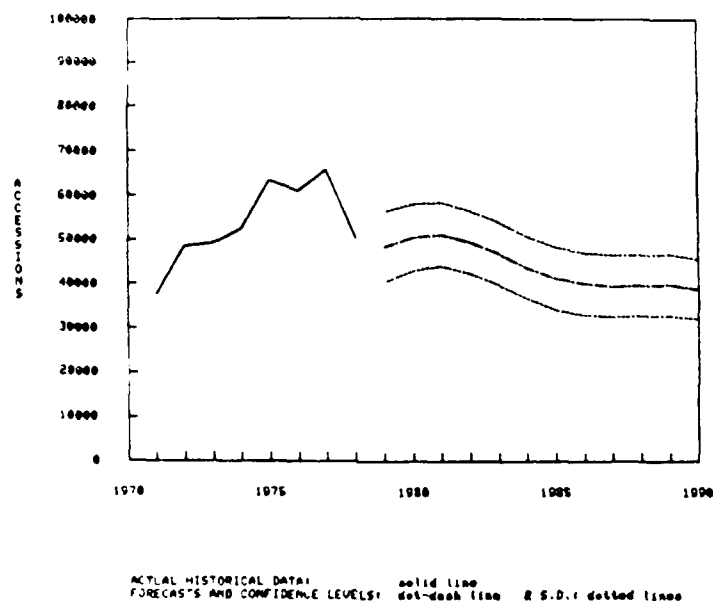
The fact that the model changed during the test period makes it difficult to analyze forecasts or forecast residuals from period to period. If both sides of (6a) are multiplied by P_t , we obtain

$$A_t = K P_t S_t^b R_t^c U_{t-2}^d e^{\epsilon_t} \quad (6b)$$

which, by assumption, has forced a linear dependence between accessions and population pool. We mention this relationship as it differs from the findings of Morey [1979] where the coefficient P_t obtained by regression was found to be substantially less than one.

Forecasts and confidence intervals based on errors of the Case B scenario reported by Fernandez [1979] are plotted in Figure 3. The definition of this accession

FIG. 3: FORECASTS AND CONFIDENCE INTERVALS--FERNANDEZ, CASE B [1979]



cohort is Male HSDG NPS MGI-III, with a moderate salary growth pattern. As we have mentioned earlier, these confidence intervals should not be trusted, as they do not increase with the length of the forecast horizon.

Morey [1979] chooses a multiplicative lagged model of the form

$$A_t = K \prod_j P_{t-j}^{a_j} \prod_j Q_{t-j}^{b_j} \prod_j R_{t-j}^{c_j} \prod_j U_{t-j}^{d_j} e^{\epsilon_t} \quad (7a)$$

with ϵ_t a random error and parameters a_j , b_j , c_j , d_j estimated from historical data. A linear regression model is applied to the logarithms of the accessions and independent variables to find these constants.

If one neglects those terms whose exponents are less than 0.05, the model can be approximated by

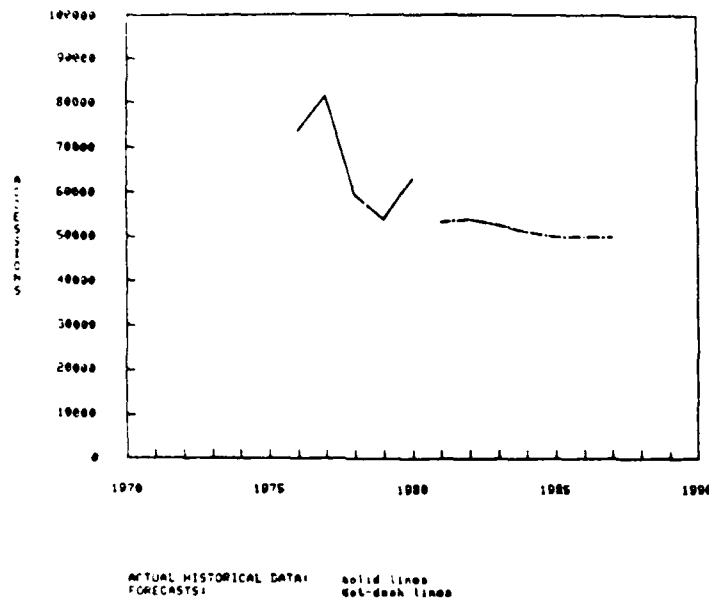
$$A_t = K P_t^{0.4} R_t^{0.3} U_t^{0.15} e^{\epsilon_t} \quad (7b)$$

Morey finds that the effects of time lags are negligible and the accessions appear to depend primarily on the manpower pool, the number of recruiters, the unemployment level, but are relatively insensitive to advertising and salary scales.

There is substantial similarity of (7b) to (6b). The major differences appear to be that (i) by assumption, A_t in (6b) is directly proportional to P_t ; (ii) the only significant lagged term is U_{t-2} in (6b) while no lags appear to be significant in (7b); and (iii) the salary contribution appears to be important in (6b) but not in (7b).

Historical accessions and forecasts obtained from the Morey [1979] model are shown in Figure 4. No confidence limits were available. Although there was no writ-

FIG. 4: FORECASTS--MOREY (JAN. 1981)



ten documentation for these forecasts, we obtained them by direct request on January 6, 1981 from LCDR Thalman in the U.S. Navy Recruiting Command. The forecasts of accessions refer to non-prior service high school degree graduates, including reservists, mental groups I-III (NPS HSDG MGI-III).

The Goldberg [1979] model differs from the above in at least one significant way. The attractiveness of the U.S. Navy as a career is assumed to be standards-dependent and includes terms which measure the discrepancy between actual accessions and preannounced manpower goals, the idea being that mental group categories are constantly being redefined. Typically, standards are lowered if manpower goals are not met, and the standards are raised when supply exceeds manpower goals. It is the experience of Goldberg that the presence of manpower "shortfalls" automatically leads to a corrective influence which either changes goals or accessions in following periods.

In his model accessions are viewed as a fraction of chargeables, C_t , where chargeables are a substitute for U.S. Navy quotas:

$$A_t = \phi_t C_t \quad 0 < \phi_t < 1 \quad (8)$$

and

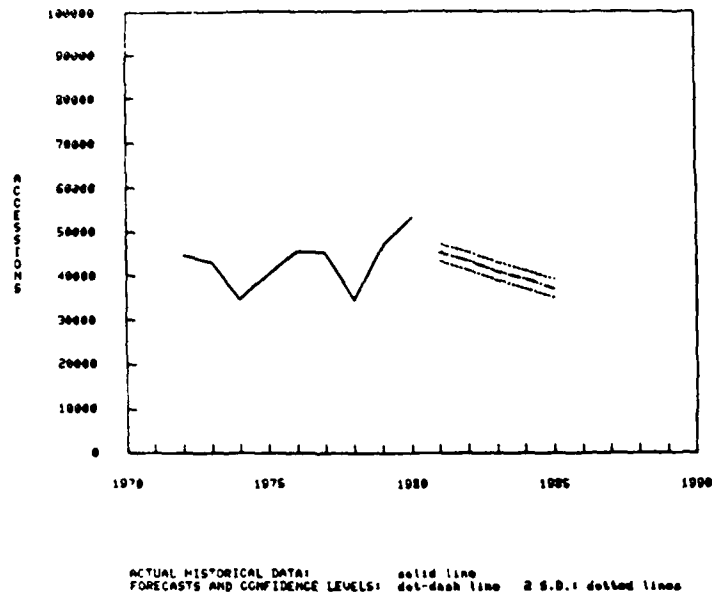
$$\phi_t = K + aP_t + bQ_t + cR_t + dS_t + eU_t + fC_t + \epsilon_t. \quad (9)$$

By substituting (9) in (8) we see that accessions, A_t , depend quadratically on C_t . As before, the constants a through f are obtained from regressions of A_t/C_t on the other variables. It should be pointed out that the measure of advertising used in these models is an exponentially weighted average of historical advertising budgets rather than the most recent advertising budget which leads to certain unresolved difficulties in parameter estimation.

Goldberg's analysis of data reflects two different periods. In the first period (1970-1977) goals were lowered and standards were raised because supplies of manpower exceeded requirements. Since 1978 the reverse appears to be true, namely there are shortfalls because supplies cannot meet requirements even when standards

are reduced. Figure 5 is a plot of historical and forecast accessions and confidence limits for NPS HSDG MGI-III cohorts of Goldberg. The confidence limits were not

FIG. 5: FORECASTS AND CONFIDENCE INTERVALS--GOLDBERG [MAY 1980]



available from any written documentation but were obtained from telephone conversations with the author during January 1980. Again, it should be pointed out that the confidence limits are based on the author's guesses regarding standard errors for estimated parameters, not on the calculation of forecast residuals.

While the inclusion of demand-limited or supply-limited variables is important conceptually and appears to give good statistical fits during the test period, there are several logical inconsistencies and technical difficulties with the Goldberg model. The first is that the specific form of the model is designed to account for the demand-limited period (1970-1977) when supplies exceeded requirements and standards were raised. In the post-1978 period the reverse situation appears to be in effect, i.e. standards have been lowered in order to meet goals in a supply-limited market. If an important time-dependent demand-supply model shift has indeed occurred, it does not seem that the model which gives a good fit to the early period should automatically be used to forecast and study policy implications in the later period. Secondly, there are

serious deficiencies in either the model structure or the estimation technique if predicted values of the dependent variable, ϕ_t , during the test period range over inadmissible values while a single independent variable, P_t , varies over actual observed values. One's suspicion is that either the econometric model is improperly specified or the parameter estimation technique should have explicitly included upper and lower bounds on ϕ_t . Thirdly, the highly correlated residuals also suggest that the model is improperly identified. Fourth, since the problem of forecasting chargeables, C_t , is left open, the user of the CNA model still faces a major unsolved forecasting problem. To assume that chargeables will remain constant during the 1980-1990 period seems unreasonable and unrealistic to this reviewer.

4. AN ADAPTIVE AUTOREGRESSIVE MODEL

It was surprising to this reviewer that modern time series and economic forecasting methods were not used by the authors. For a general review of the theory including examples and case studies see the book by Granger and Newbold [1977]. This concern is shared by other reviewers, particularly since the authors frequently report significant autocorrelations in curve-fitting residuals. If such correlations are indeed significant, that feature should be included in the design of the supply forecasting model, not simply in the estimation procedure.

To address this question and at the same time provide some idea of the forecast errors which might be projected for the 1980-1990 period I used a simple time-dependent first order autoregressive model

$$A_{t+1} = \phi_{t+1}P_{t+1} + a_{t+1} \quad (1a)$$

$$\phi_{t+1} = \phi_t + b_{t+1} \quad (1b)$$

where a_t , b_t are stationary zero-mean uncorrelated random noise terms with variances σ_a^2 , σ_b^2 ; ϕ_t is the (random) fractional accession rate and A_t and P_t are the accessions and pool size in period t . This model has several desirable features, which, through its autoregressive structure, capture the (possibly) complicated behavioral dependence of historical enlistment patterns.

- (i) the fractional accession rate is a time dependent random variable allowing for unstated but possibly complicated behavioral patterns
- (ii) both the expectation and variance of future accessions vary with time and data.
- (iii) at any given time period t , the forecast errors or confidence limits increase with the square root of the forecast horizon, i.e., the further ahead one looks, the less the confidence in one's forecasts.

(iv) the updating rules for revising the parameter ϕ_t have a structure similar to well-known exponential smoothing methods.

Suppose that at time t one obtains the conditional expectations and variances

$$\hat{\phi}_t = E[\phi_t | A_t, A_{t-1}, \dots] \quad (2a)$$

$$\hat{p}_t = Var[\phi_t | A_t, A_{t-1}, \dots] \quad (2b)$$

Then the k -period forecasts $f_{t,k} = E[A_{t+k} | A_t, A_{t-1}, \dots]$ and $v_{t,k} = Var[A_{t+k} | A_t, A_{t-1}, \dots]$ are given by

$$f_{t,k} = E[\phi_{t+k} P_{t+k} + a_{t+k} | A_t, A_{t-1}, \dots] = \hat{\phi}_t P_{t+k} \quad (3a)$$

$$v_{t,k} = P_{t+k}^2 (\hat{p}_t + k\sigma_b^2) + \sigma_a^2 \quad (3b)$$

Note that the forecasts in (3) satisfy one's intuitive feelings about future accessions: (i) expected future accessions are the product of today's "best" estimate of the accession rate times the future manpower pool, and (ii) the variance of these forecasts grow linearly with how far ahead one looks.

To give the reader some idea of how the expected value of the accession rate and forecasts vary over time note that

$$\hat{\phi}_t = 0.005 \quad \hat{p}_t = 2.5 \times 10^{-7} \quad (4a)$$

are probably the right order of magnitude for the expected fractional accession rate and its uncertainty given a pool size of approximately 10 million people and 50,000 accessions per year. Under such assumptions the square root of \hat{p}_t is equal to 0.0005, which can be thought of as an annual standard deviation in the fractional accession rate. In other words, we assume *a priori* that the uncertainty in the accession rate is about 10% of its expected value. Let us also assume that yearly variations in the accession rate have equal variances so that $\sigma_b^2 = 2.5 \times 10^{-7}$, while a typical measurement error associated with accessions is probably about 1,000 people or $\sigma_a^2 = 10^6$ people. With a population pool of 10 million people the variance in future accessions is given by (3b), as

$$v_{t,k} = 100 \times 10^{12} \times 2.5 \times 10^{-7} (1+k) + 10^6 = (25(1+k) + 1) \quad (4b)$$

or a standard deviation in forecast accessions k periods from now equal to

$$\pm \sqrt{v_{t,k}} = \pm \sqrt{1 + 25(1+k)} 10^3.$$

One year from now ($k=1$) a typical forecast error might be

$$\sqrt{v_{t,1}} = 7,141.$$

Five years from now ($k=5$) the typical forecast error would be slightly less than double that value,

$$\sqrt{v_{t,5}} = 12,288.$$

Figures 6 and 7 are graphs showing the expected accessions and their confidence limits using the models in Equations (2) and (3) above and the manpower pools in

FIG. 6: FORECASTS AND CONFIDENCE INTERVALS--OLIVER, USING 1978 DATA

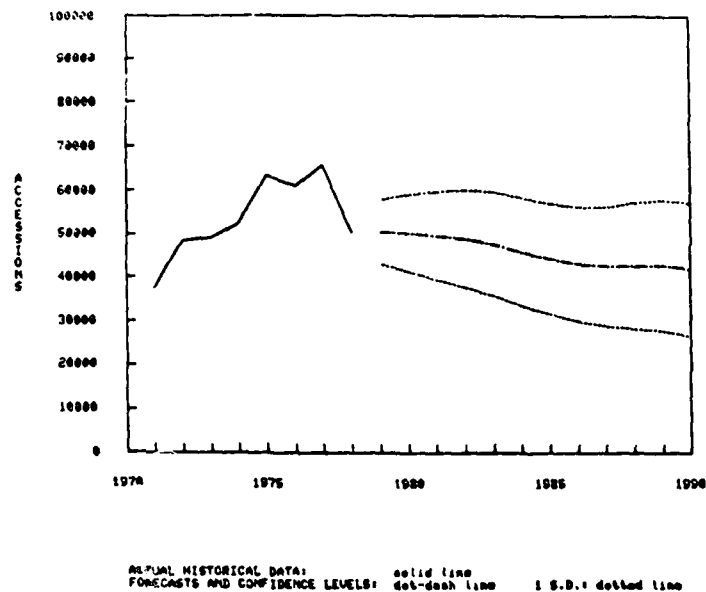
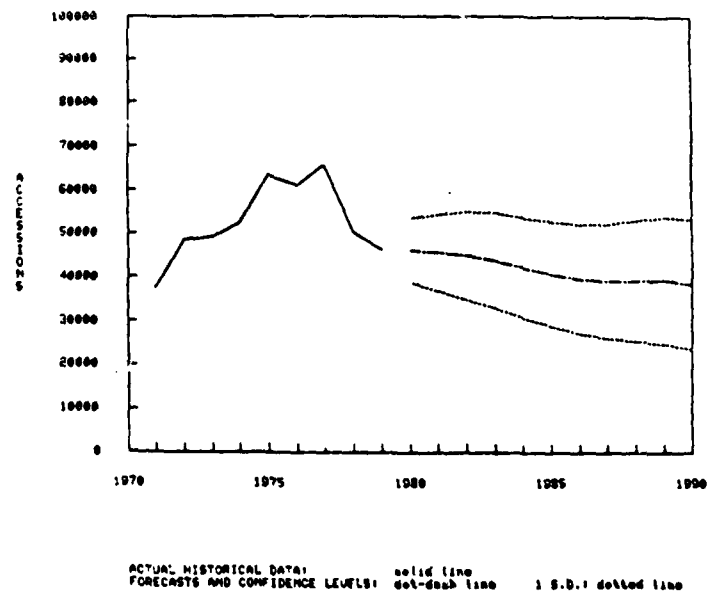


FIG. 7: FORECASTS AND CONFIDENCE INTERVALS--OLIVER, USING 1979 DATA



Appendix B.7 of Fernandez [1980]. The updating formulas for $\hat{\phi}_{t+1}$ in terms of $\hat{\phi}_t$ and \hat{p}_{t+1} in terms of \hat{p}_t and historical data are simple modifications of adaptive Bayesian filters described by Oliver and Nau [1979]. It is interesting to note that the actual 1979 accessions (Fernandez [1980]) minus the forecast made for 1979 in 1978 lies well within the predicted forecast error. By properly including other important exogenous and policy variables it should be possible to reduce the size of the confidence band, possibly by as much as a factor of two.

A model that seems worthy of further consideration is one which takes into account manpower pool size, and unemployment levels, and recruiting policy in a multiplicative form such as

$$A_t = U_t^{\phi_t} (P_t - U_t)^{\theta_t} R_t^{\xi_t} e^{a_t} \quad (5a)$$

$$\phi_t = \phi_{t-1} + b_t \quad (5b)$$

$$\theta_t = \theta_{t-1} + c_t \quad (5c)$$

$$\xi_t = \xi_{t-1} + d_t \quad (5d)$$

where a_t , b_t , c_t , d_t are random noise terms, U_t and $P_t - U_t$ are the unemployed and employed manpower pools, and R_t is the recruiting effort. The role of the "attractiveness" parameters ϕ_t , θ_t , ξ_t are more apparent if we write the logarithm of accessions in (4a) as

$$\ln A_t = \phi_t \ln U_t + \theta_t \ln (P_t - U_t) + \xi_t \ln R_t + a_t \quad (5e)$$

5. SUMMARY AND RECOMMENDATIONS

- (1) To test the accuracy and usefulness of each model one should, using a standard and comparable set of data, over a given test period, make forecasts of accessions and compare them with actual accessions.
- (2) Authors of these models should be asked to calculate confidence intervals for forecasts in future time periods. Reject out-of-hand any models whose confidence intervals decrease with the length of the planning horizon.
- (3) Each author should identify the sources and magnitudes of future uncertainties, such as unpredictability in unemployment levels, unpredictability in manpower pools, advertising, etc.
- (4) Each author should clearly state whether his forecasts are based on a given future scenario for policy and exogenous variables or whether uncertainties in those variables are also included in the accession forecasts. In other words, carefully distinguish between unconditional and conditional forecasts.
- (5) Have each author compute and analyze one-step-ahead forecast errors computed as they would have been calculated in real time. The emphasis should be on *forward-looking* forecast errors, not on *backward-looking* residuals, and the analysis should base forecasts on historical data that would have been available at the time the forecast was computed.
- (6) Insist on comparability and consistency of cohort data. For example, forecasts of NPS HSG MGI-III *including* reservists should not be compared with actuals that *exclude* reservists.
- (7) Greater attention should be given to the problem of forecasting different types of cohorts, such as different mental groups, reservists, non-reservists, high-school graduates, etc.
- (8) Encourage the development, design, implementation, and testing of simple forecasting models based on a few common-sense parameters which explicitly include policy variables and the reported presence of autocorrelated structure. Exponential smoothing and Bayesian level and trend models should certainly be included as model candidates.
- (9) Continue the practice of in-depth "entrance" interviews for selected HSDG Mental Group I-III who do and do not enlist in order to compare and evaluate the reasons and factors which make the U.S. Navy a desirable career, thus influencing the "attractiveness" parameters (ϕ_t , θ_t , ξ_t).
- (10) Investigate the possibility of a permanent professional recruiting force within the recruiting commands. Take steps to increase the low productivity of recruiters who are currently on a three year tour of duty.
- (11) Offer substantial financial incentives to productive recruiters for obtaining enlistments. This policy contrasts with current financial incentives to new enlistees or increased pay incentives to all military personnel.

BIBLIOGRAPHY

- Bass, Frank M. [January 1981] Analysis of Navy Personnel Supply Model, Report presented at ONR Conference, January 22-23, 1981, Washington, D.C.
- Chazen, S. [October 1977], "Macro Forecasting with ARIMA Models," Data Resources Review, pp. 12-25.
- Cralley, William E. [September 1979] The Supply of Marine Corps Recruits— A Micro Approach, Center for Naval Analysis, 101 pp. + appendices.
- Eckstein, O. [September 1979], "Econometric Models For Forecasting," Data Resources U.S. Review, pp. 34-47.
- Fernandez, Richard L. [February 1980] Enlisted Supply in the 1980s, Rand Corp. Working Draft WD-515 MRAL. 27 pp.
- Fernandez, Richard L. [September 1979] Forecasting Enlisted Supply: Projections For 1979-1990, N-1297-MRAL. A Rand Note prepared for the Office of the Assistant Secretary of Defense/Manpower, Reserve Affairs and Logistics. 92 pp.
- Goldberg, Lawrence [December 1980] The Supply of Navy Enlistments, Center for Naval Analyses, Report 80-1771, 41 pp.
- Goldberg, Lawrence [May 1980] Long-Range Planning of Requirements for Navy Recruiters and Advertising, Center for Naval Analyses, Report 79-1625, 18 pp. + 2 appendices.
- Goldberg, Lawrence [April 1980] CNA and Rand Forecasts of Navy Enlistments, Center for Naval Analyses, Report 80-0393, 10 pp.
- Goldberg, Lawrence [March 1980] Recruiters, Advertising, and Navy Enlistments, Center for Naval Analyses, Professional Paper 275, 34 pp.
- Goldberg, Lawrence [October 1979] Recruiters, Advertising, and Navy Enlistments, Center for Naval Analysis CRC 409, 25 pp. + 3 appendices.

- Granger, C.W.J. and Paul Newbold [1977] Forecasting Economic Time Series, Academic Press, N.Y., 333 pp.
- Morey, Richard C. [October 1979] Budget Allocation and Enlistment Prediction Models for the Navy's Recruiting Command: Testing and Validation, The Center for Applied Business Research, Duke University, 40 pp.
- Morey, Richard C. [July 1980] The Impacts of Various Types of Advertising Media, Demographics, and Recruiters on Quality Enlistments: Results from Simultaneous and Heteroscedastic Models, The Center for Applied Business Research, Duke University, 71 pp.
- Morey, Richard C. and John M. McCann [Dec. 1980] "Evaluating and Improving Resource Allocation for Navy Recruiting," Management Science, vol. 26, no. 12, pp. 1198-1210.
- Nau, R.F. and R.M. Oliver [1979], "Adaptive Filtering Revisted," Journal of Operations Research Society, vol. 30, no. 9, pp. 825-831.

ANALYSIS AND PERSONNEL SUPPLY MODELS

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Introduction

In preparing for this workshop, I had the opportunity to read and work through a substantial quantity of research on the supply of Navy recruits. This material included two studies by the Rand Corporation [1,2] five studies by Duke University [9,10,11,12,13] and five studies by the Center for Naval Analysis [3,4,5,6,7]. Because of the volume of work involved, I will not comment in detail about each of the studies. Also, I shall try not to duplicate the comments of my colleagues Professors Bass and Oliver.

We were asked to address several questions in our comments on the studies. While I will have something to say about each of the questions, I will focus my comments on the general question, "How are these analyses best used by the consumer?" To answer this we must first understand what analysis is and what it is not.

The Value of Analysis

The world of the problem, the decision making environment is characterized by a large quantity of data. Our problem is not usually one of too little data but too much. This data is of uneven quality, however.

This is also a world of conflicting objectives - more recruits vs higher quality recruits; and a world of diverse opinions about how to achieve those objectives.

Analysis cannot solve these problems. Analysis is research; but it does not yield the "right" answer. Analysis is a highly structural way of looking at the problem. It is designed to shed light on only some aspects of the problem.

Analysis has value though. Analysis provides motivation to quantify the objectives thereby forcing us to be more precise about goals. Analysis also focuses the data. It provides the procedure to distill and filter the data, transforming it into useful information about some aspects of the problem.

Analysis also incorporates the risks and uncertainties inherent in decision making and, perhaps more importantly, it provides an organized basis for discussing the problem and alternative solutions to it.

In assessing analysis and in using it in decision making several questions should be asked. They should also be kept firmly in mind by those performing the analysis.

The Problem

The first, and most important, of these questions is, "What is the Problem?" Frequently, answering this question requires a careful look at the organization which requires the analysis. Often "the problem" will be stated in different

forms at different levels within the organization. Understanding the problem often requires understanding the objectives of the entire organization.

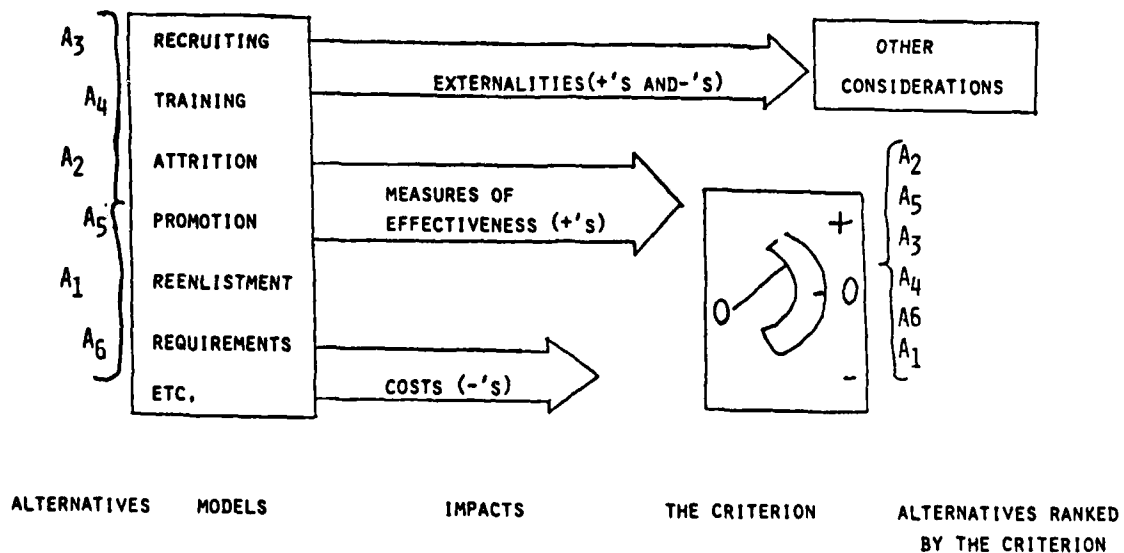
In this case what is the problem?

The Number of Male Recruits
 The Number of Male High School Graduates Recruited
 The Distribution of Recruits by Sex and Education
 The Number of Unfilled Billets by Type
 The Skill Structure of the Navy
 Naval Warfare Effectiveness Over Time

Operationally we must choose to look at the problem at some level - we can't hope to deal with the most general problem in each analysis. Choosing the level of analysis involves a trade off. Frequently, we must trade off ability to measure against sub-optimization as we consider alternative levels of analysis. This is illustrated in Figure 1 where the decision to be made is characterized as choice among alternatives.

FIGURE 1

THE ELEMENTS OF SYSTEMS ANALYSIS



If we consider the problem at a low level, say the number of recruits, we can get by with fewer models. Ordinarily the number of alternatives that need to be considered is smaller too. We can measure effectiveness and costs of the alternatives precisely in terms of the objective. And, we can combine these measures easily into a criterion which ranks the alternatives. But, by focusing on the low level problem, we ignore the costs and measures of effectiveness that are external to our analysis, the externalities. Thus, we increase the chances that the choice will be driven by "other considerations." In this case we have sub-optimized.

Alternatively, we may consider the problem at a relatively high level, say the skill structure of the Navy over time. Here we require many kinds of models to analyze the problem. The models must evaluate a large number of kinds of alternatives. These models generate many measures of effectiveness and costs, but few externalities. The process of combining all these measures into a single criterion is fuzzy at best and the process generates significant uncertainties about the criterion and the choice among alternatives. So in the attempt to move from sub-optimization to optimization, we decrease our ability to measure the criterion precisely.

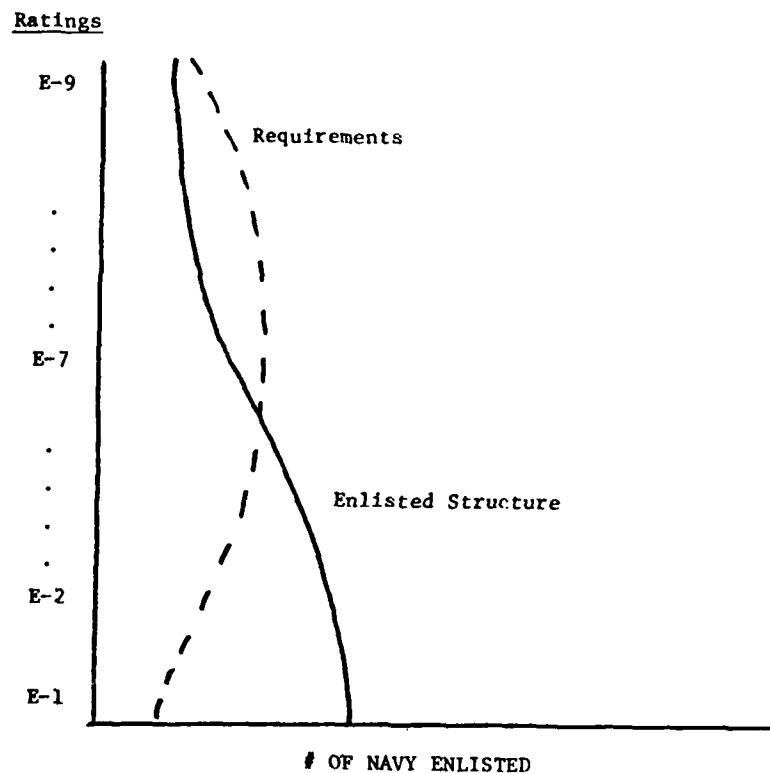
There is no right answer to this dilemma. But we must ask, "Is the analysis of the supply of recruits broad enough to shed light on the relevant problem? Furthermore, if not, "how does the analysis fit into the larger problem?" These questions provide the necessary perspective for evaluating and using the analyses. They help us understand why the analyses are different in some respects and in what direction they might be expanded.

One direction in which all the analyses which were submitted can be expanded is in the direction of including impacts of the other services on recruiting. This will probably require a system of equations approach to modeling the recruiting problem. At the very least, the Rand data [2] could be used with Joint Generalized Least Squares to capture some of the interaction among the services.

A second area for expansion of the analyses is in the retention and re-enlistment area. To a large extent the retention decision is motivated by the same economic factors that motivate enlistment. Retention changes in turn are the major causes of quota changes for recruits. This is true mainly because the demand for recruits is a derived demand - derived from a demand for trained

personnel in higher ratings. Figure 2 illustrates this point. A single attrition in the higher ratings may create a demand for several recruits because of the difficulty in growing a trained NCO.

FIGURE 2
RELATIONSHIP BETWEEN MANPOWER REQUIREMENTS BY RATING
AND MANPOWER POOL



Expanding the analysis in this direction may also help with the problem of measuring the quality of Navy recruits. We have already heard that recruiting standards were relaxed in FY 77 and then tightened up in FY 78. The attrition data in Table 1 seems to reflect this change in standards, at least during the

TABLE 1

NAVY ENLISTED ATTRITIONS AS A PERCENTAGE OF ENLISTMENTS

| YEAR OF ENLISTING | TIME SINCE ENLISTING | | | |
|-------------------|----------------------|--------|---------|---------|
| | 6 MO. | 1 YEAR | 2 YEARS | 3 YEARS |
| FY 80.1 | 10.82 | | | |
| FY 80.2 | 11.07 | | | |
| FY 79 | 11.17 | 15.81 | | |
| FY 78 | 11.82 | 15.89 | 22.35 | |
| FY 77 | 14.66 | 19.46 | 26.26 | 30.30 |
| FY 76 | 10.55 | 17.44 | 27.46 | 32.38 |

first year of enlistment. One way to combine recruiting and retention is to attempt to explain the number of "effective recruits" which we might define as those that are still in the Navy at the one year point. Of course, this involves modeling more than the recruiting function; but it does get us closer to the larger, more relevant problem.

Expanding the analysis to include retention and re-enlistment models logically suggests expanding the number of alternatives that should be considered. That is, if the objective is to improve the quantity and mix of skills in the Navy then some alternatives that do not involve recruiting must be considered.

For example, each of the following pure alternatives along with mixes of the alternatives should be considered by the analysis.

Advertising
More Recruiters
Selective Enlistment Bonuses
Educational Benefits
More Training
Re-Enlistment Bonuses
More Automation

Modeling Methodology

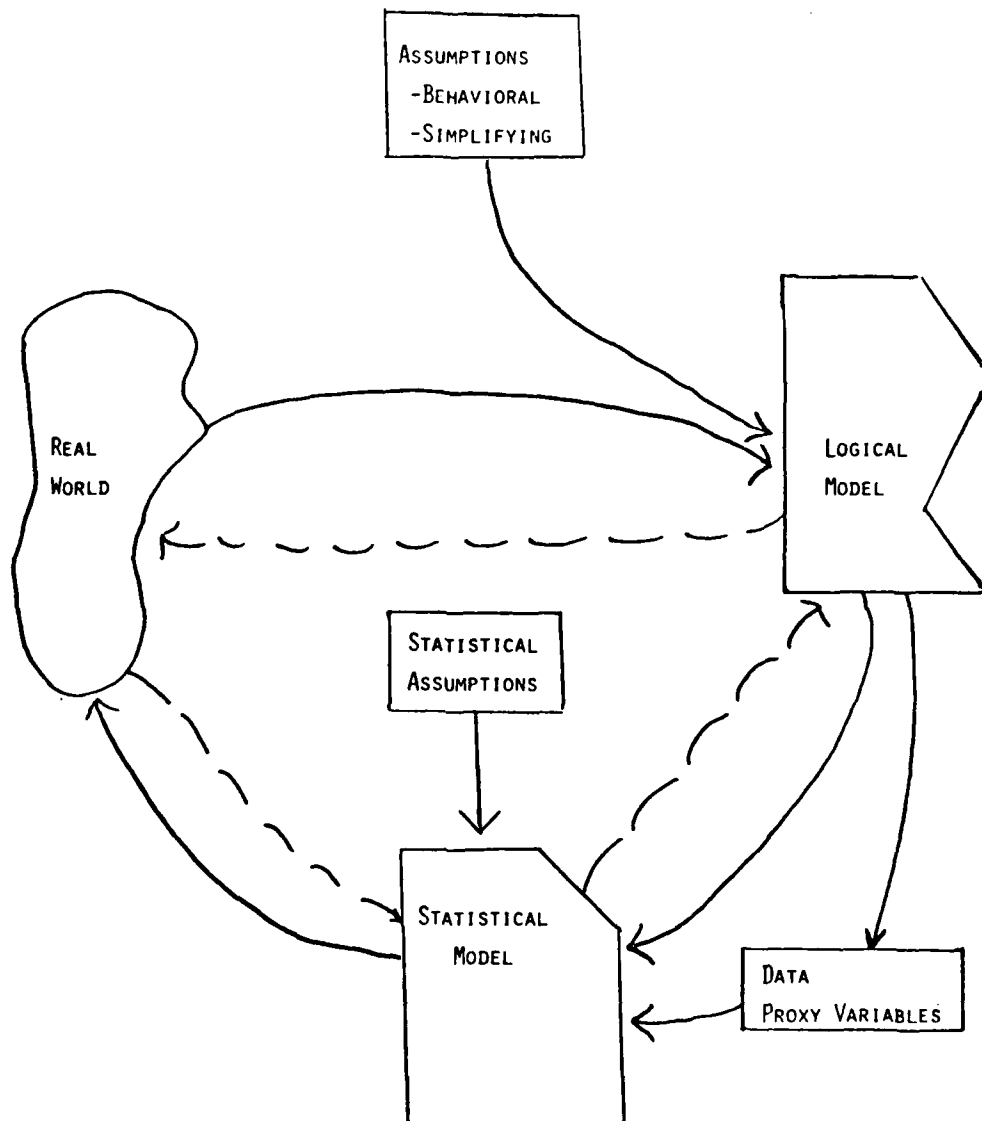
Most of the issues which we were asked to address concern the form of the supply models. Implicit in these issues is, I believe, some concern about the fact that the three sets of models are very different from each other. To understand these differences we must understand the functions of models in analysis.

Models perform two functions in analysis, a descriptive function and a predictive function. In the descriptive function the model describes the relations among variables. This description includes both the intensity and the direction of the relation. In addition, the precision with which these relations are measured is usually reported. In the predictive function, the model predicts values of the dependent variables given values for the exogeneous variables. In this use the conditions of the prediction and the precision of the prediction are usually reported. The special case where the variables are predicted for a future time period is called a forecast.

If we were only interested in forecasting the future supply of Navy recruits, we could make use of models that have been designed primarily for forecasting. These time series models, developed in the electrical engineering area, emphasize the time structure of the observations and deemphasize the contemporary interaction among variables in the models. Because there is very little theory about the time structure of economic variables, these models rely heavily on testing many alternative time structures. As a result, they require a rather large amount of time series data to efficiently estimate the parameters.

However, to be useful in analysis, the models must be able to evaluate the differences among alternative conditional predictions. That is, they must be able to evaluate costs and measures of effectiveness for alternative actions. In order to do this they must not only forecast but also accurately describe the relations among the variables of the models. This requires that we pay careful attention to the contemporaneous structure of the model as well as its time structure. Furthermore, since data is scarce, we cannot rely only on testing for guidance in model development. As a result, we are forced to make use of assumptions and a sequential approach to model development. This approach is illustrated by Figure 3.

FIGURE 3



This approach starts with assumptions. Assumptions are lies about the real world. They are not intended to be true; they are made to simplify our view of the real world. Assumptions are necessary because the real world is very complex. In order to understand it we must deal with only a portion of it. They are also

necessary because there cannot be enough data to test all of the hypotheses about the real world - so we assume that some hypotheses are at least approximately true and test a very small number of the others.

The process of modeling in econometrics involves the construction of two models. The first, the logical model, is based on perceptions about the real world, axioms of behavior, logical deduction and simplifying assumptions. The logical model is a dramatic simplification of the real world. It specifies a few of the important relations among a small number of variables that are thought to be important in describing real world phenomena.

The logical model specifies the variables on which data is to be collected to support the empirical work. Sometimes the variables in the logical model cannot be measured at a reasonable cost - perhaps not at any cost. In these cases the logical model must be revised and proxy variables must be introduced to the analysis. The logical model, data, proxy variables and statistical assumptions all play a role in determining the statistical model that is finally estimated.

This model building process also involves testing and feedback. The logical model is tested for consistency against the real world. It should be determined that no previously observed phenomena violate the model. Likewise, the statistical model is tested against the logical model. In this process we make sure that the net effect of data, proxy variables, and statistical assumptions do not violate the spirit of the logical model.

Only after this process is complete are we ready to compare the statistical model to the real world. Only then can we estimate the relations of the statistical model and conduct the few tests that our typically meager supply of data permit. The statistical model may be revised based on these test results; but if the relations are to be reliably estimated only a few iterations of testing and revision are possible.

This is the procedure used in the Rand study [2]. Here the Durbin-Watson statistic was used to test for first order positive autocorrelation in the error term. The null hypothesis of serial independence was rejected in favor of the alternative and the Cochrane-Orcutt technique was employed. The Cochrane-Orcutt technique has two attributes. First, it is a new specification of the model; one with a first order autoregressive structure of the error term. Second, it is a method for estimating the newly specified model. Hence, this procedure is just the procedure of specifying a statistical model, testing one of the elements of the specification, revising the specification and estimating the revised model.

The CNA model [6] followed the same procedure for dealing with autocorrelation and the Duke study [2] used Park's method which is the analogue of the same procedure when dealing pooled cross-section and time series data.

In each case the studies seem to be resting on firm methodological ground. But if this is true then, "why are they different?"

Model Details

The first, and most obvious difference among the studies concerns the data. The early CNA studies [4,6] use 26 quarterly observations on Navy Contracts over the period 1971.3 to 1978.4. The Rand study [2] used 98 monthly observations on accessions in each of the four services. Rand's data applied to the period July 1970 to September 1978. The Duke studies [9,12] used 36 monthly observations on Navy contracts in each of the 43 recruiting districts over the period January 1976 to December 1978. This pooled data set amounts to 1,548 observations which were analyzed together. The later CNA study [5] used three yearly observations on Navy contracts in each of the recruiting districts. This generated a pooled sample of 129 observations over the period 1977 to 1979.

These large differences in the quantity of data, in the type of data, and in the time periods over which the data were collected were almost sure to require different statistical models and different estimation techniques. Therefore, different results were produced. Given this situation it is heartening to see how similar the results of the models are.

A second way in which the analyses differed from each other concerns the uses of indicator (dummy) variables. This was one of the specific issues we were asked to address.

Indicator variables were used in at least three different ways by the studies. To some extent, the appropriateness of their use depends on how they are used. Nevertheless, indicator variables should generally be viewed as a last resort, to be used only if the phenomena can be adequately described in no other way.

The most troublesome use of indicator variables is in the description of unexplained, one time events. For example, the Rand study's FY 78 indicator variable, CNA's GIBL, NACPL, and AVF variables, and Duke's yearly dummy variables and the indicator for the GI Bill. In each of these cases the variable is associated with some one time event--which may or may not have something to do with the ending of the GI Bill for example. Generally, it would be more appropriate to model the effect of policy changes on other explanatory variables in the system rather than to use indicator variables.

For example, instead of using a indicator variable, the effect of the change in the GI Bill on a potential recruit's lifetime income could be included with relative military pay and the net effects of income changes could be estimated.

While this approach is more desirable, indicator variables are popular ways to handle these problems, at least as temporary solutions.

Other uses of indicator variables are less objectionable. The use of indicator variables to model repeated events (seasonal and monthly variations) is frequent and probably justified. All three studies do this. Also, the Duke study's use of geographical dummy variables seems to be appropriate. However,

it is not clear that variations in the coefficients of these dummies are attributable to any particular event.

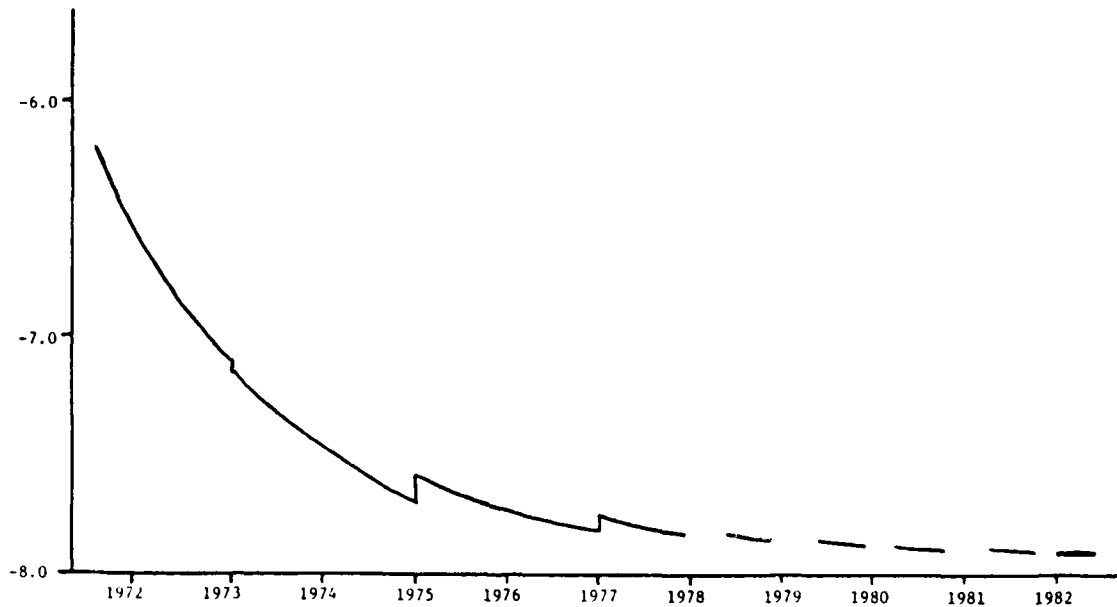
A modeling technique with an effect similar to that of dummy variables is a trend factor.

While the use of $X(11)$ in the CNA study is well motivated, the effect of $X(11)$ is to include a time trend in the estimated relation. The net impact of the dummy variables and the time trend on the predicted number of high school graduate contracts per chargeable is the subject of Figure 4. The relation graphed there is

$$Z = -7.99 + 2.01 X(11) + .0453 \text{ GIBL} + .0972 \text{ NAVPL} - .043 \text{ AVF}$$

where Z is the estimated effect of exogeneous factors (other than the seasonal dummies) on the dependent variables.

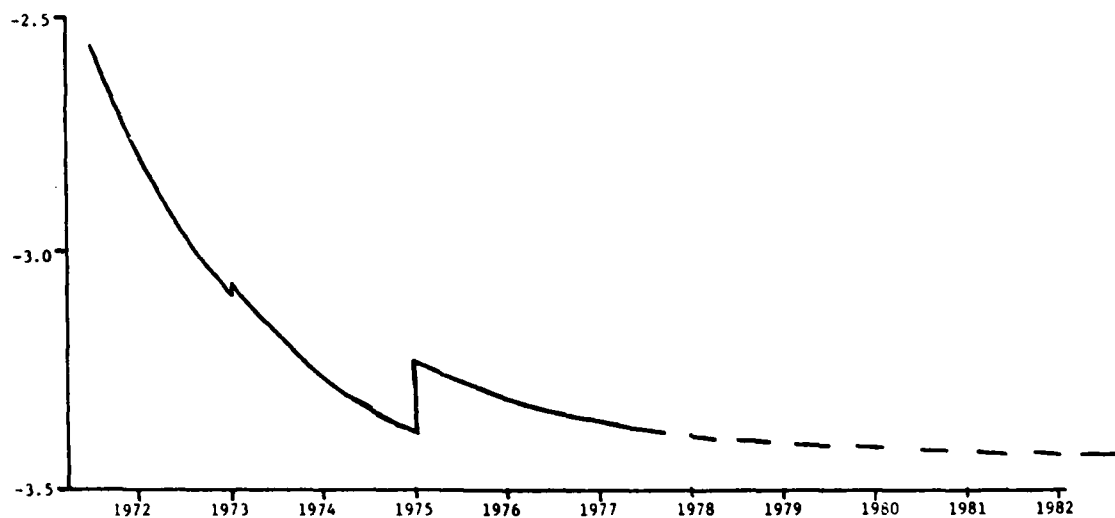
FIGURE 4
CRC 409
% HSG
EXOGENEOUS TRENDS



Over the 26 quarter period of the study (the solid line) these factors have a dramatic effect. The estimated impact of these factors is to reduce the dependent variable by 1.7 units over the period of the study. But the dependent variables is restricted to be between 0 and 1; and over this period it never fell outside the range .61-.88. Thus, the negative effect of these exogeneous variables is dramatically over estimated. These over estimates are

offset by two variables that are highly negatively correlated with $X(11)$, population and $Y(11)$, depreciated advertising. It seems clear that the equation overestimates the impact of population and/or advertising to provide a good fit. So long as these three variables tend to remain highly correlated, this multicollinearity situation will not effect forecasts; but, in the next 30 quarters $X(11)$ goes from .0303 to .0009 with an impact of only .0603 to .0002 on Z while population and advertising are not likely to maintain the steady path that they were on. Hence, we likely overestimate the impact of both population and advertising on recruits. Figure 5 depicts a similar situation for the upper mental category contracts.

FIGURE 5
CRC 409
Z MG 1-3u
EXOGENEOUS TRENDS



Still another issue concerning the analyses is the modeling of advertising. One concern, "is the function an S-shaped curve?" is probably a moot point. If the Navy is advertising at anywhere near the appropriate rate, then we should be into the diminishing returns portion of the S-shaped curve if it exists. Under these circumstances a log linear relation should serve quite nicely as a specification of the relation over the relevant region.

The second concern, whether advertising should be modeled with disturbed lags or using capital stock methods is probably not of much practical importance either. The difference between using a Koyck distributed lag and the stock of

awareness capital is mainly a choice of estimation procedure rather than a different specification. The awareness capital approach is somewhat more specific to advertising than the distributed lag approach, but it also requires non-linear techniques and is therefore subject to slightly more estimation error. The approaches should produce similar results on the same set of data, however. Since almost all of the models correct for autocorrelation in addition to these effects, it is just not clear what the net effect of the alternative specifications are.

A general problem, shared by most of the models is autocorrelation. The authors recognize that this is a problem, and they use appropriate techniques to test for it and to estimate in the presence of autocorrelation. However, they seem to forget about autocorrelation when they make forecasts. Goldberger [8], in a classic article that has now found its way into most textbooks, shows how to predict in the presence of autocorrelation. Generally, if autocorrelation is important enough to be considered in estimation, it is important in prediction too. This is particularly true for near term predictions.

In addition to the previous comments the following apply to the Rand studies [1,2]. Generally, it seems that contracts would provide more accurate results than the accessions data that was used. Secondly, given the data sets it would seem that Joint Generalized Least Squares, if not some more explicit relation among the service equations, would be appropriate. The Rand model uses unemployment as a variable, but it is not clear to me that seasonally adjusted unemployment is the appropriate measure for eighteen year old decision makers.

In the Duke study [12], the eight equation system is recursive. That is, there is no contemporaneous feedback in the system. Under these circumstances two stage least squares need not be used to estimate the system -- ordinary least squares will do quite nicely. Also the system lends itself to Park's technique. The application of this technique to the eight equation system should improve the quality of the estimates.

Also with respect to the eight equation system, I think that a variable that is the difference between the quota and the number of high school graduate contracts would be very important in explaining the number of non-high school graduate contracts. At least much of the discussion in the other studies implies this conclusion.

In addition to the forecasting bias introduced by the time trend discussed above, other aspects of the CNA study also deserve some comments. The early study [6] suffers from a degrees of freedom problem. With only twenty-six observations sixteen parameters were estimated. There just aren't enough observations to estimate this many parameters accurately. To use the model for forecasting, one must have a reliable forecast of the total number of recruits (chargeables). While chargeables have been highly correlated with the quota in the past, they may not continue to be in the future.

When this model was used to forecast, the coefficient of population was arbitrarily changed to produce meaningful results. This indicates the authors lack of confidence in the model.

The later CNA model [5] overcomes many of these problems. The two equation system seems to indicate a good fit for predicting contracts as a function of leads. Unfortunately, leads are not predicted very accurately by the system and the net result may be poor forecasts. This new approach is clearly just started; so confidence in these results must await the careful investigation of autocorrelation and heteroscedasticity in the model.

Finally let me say that the major goal of analysis is not to solve problems, but, to quote General Kent, "to illuminate the problem." Judged from this perspective, all of the analyses have been successful in that they each deepen our understanding of the recruiting problem.

REFERENCES

1. Fernandez, Richard L., Enlisted Supply in the 1980s, The Rand Corporation, WD-515-MRAL, February, 1980.
2. _____, Forecasting Enlisted Supply: Projections for 1979-1980, The Rand Corporation, N-1297-MRAL, September, 1979.
3. Goldberg, Lawrence, CNA and RAND Forecasts of Navy Enlistments, Center for Naval Analyses, (CNA) 80-0393, April 1980.
4. _____, Long Range Planning of Requirements for Navy Recruiters and Advertising, Center for Naval Analyses, (CNA) 79-1625, May, 1980.
5. _____, New Analysis of Navy Enlistments, (Briefing Given at ONR/DASN(M)/CNRC Workshop on Personnel Supply Models), Center for Naval Analyses, (CNA) 81-0071, January, 1981.
6. _____, Recruiters, Advertising, and Navy Enlistments, Center for Naval Analyses, CRC 409, October, 1979.
7. _____, The Supply of Navy Enlistments, Center for Naval Analyses, (CNA) 80-1771, December, 1980.
8. Goldberger, A. S., "Best Linear Unbiased Prediction in the Generalized Linear Regression Model." Journal of the American Statistical Association, Vol. 57 (1962), pp. 369-375.
9. Morey, Richard C., Budget Allocation and Enlistment Prediction Models for the Navy's Recruiting Command: Testing and Validation, Duke University, October, 1979.
10. _____, Budget Allocation and Enlistment Prediction Models for the Navy's Recruiting Command: The Proper Balance Between Recruiter and Advertising Efforts, Duke University, May, 1979.
11. _____, Results of Validation Efforts, not dated.
12. _____, The Impacts of Various Types of Advertising Media, Demographics, and Recruiters on Quality Enlistments: Results from Simultaneous and Heteroscedastic Models, Duke University, July, 1980.
13. _____, and John M. McCann, Evaluating and Improving Resource Allocation for Navy Recruiting, Duke University, not dated.

MEASURING THE EFFECTS OF POLICY CHANGES:

POSTSERVICE EDUCATIONAL BENEFITS

Richard L. Fernandez

Rand Corporation

Among the questions posed for the three reviewers at this workshop was one regarding the use of dummy variables to measure the effects of such policy changes as the termination of GI Bill educational benefits. As a result of some work I did in 1980 as part of Rand's analysis of the Multiple Option Recruiting Experiment, supplemented by a more recent reexamination of the question specifically for this workshop, I have concluded that the only apparent alternative to a dummy variable approach in a time series analysis of enlistments--the construction of a single time series variable measuring the value of educational benefits under both the GI Bill and its replacement--is not feasible. I would like to show you today what I have learned in trying to construct such a variable, and why I believe that no time series of educational benefit levels can tell us anything useful about the enlistment effect of changing the level of such benefits, or anything more about the effect of ending the GI Bill than we already know.

Two differences in the features of the GI Bill and its replacement, the Veterans' Educational Assistance Program (VEAP), are particularly important: (1) VEAP requires in-service contributions by the enlistee, and (2) benefit levels under the GI Bill were periodically increased by the Congress. The change of programs was not inconsequential, but the GI Bill and VEAP share certain important characteristics that would appear to make them amenable to comparison. First, both offer postservice benefits, available only if the veteran attends school. Second, the benefits under each are expressed in dollar terms; there are no hard-to-quantify entitlements.

The obvious way to construct a measure of the relative values of the two programs, and to extend it to cover the entire decade of the 1970s, is to compute the present value of each package. Present value has the advantage of expressing a stream of future payments or receipts as a single number indicating its value today. It is based on the notion that people would rather have a dollar today than a dollar tomorrow, and so value tomorrow's dollar at less than they do today's. Thus they discount future dollars, and that is exactly what we do in computing present values--mirroring, we believe, the mental calculation that a potential enlistee makes implicitly in deciding whether it is worth serving in the military in order to receive support for college later.

Where there have been changes in the time pattern of payments, present value is the only way meaningful comparisons can be made. In the case of the particular programs I am examining here, the differences I noted above have led to important changes in the time pattern of payments and receipts. First, the in-service contributions required by VEAP mean that the potential VEAP enlistee sees ahead first a stream of payments, followed later by the stream of receipts that his GI Bill counterpart could foresee. If he has a strong preference for money now over money in the future, the present value of that income forgone while in the service may actually outweigh the value of the later receipts. Second, the GI Bill enlistee could reasonably have expected his benefit level to rise while he was in the service and in school, while the VEAP enlistee can have no such expectation. To account for this effect of changing expectations, and the difference in the time pattern of payments and receipts between the two programs, it is imperative that we compute present values if we want to measure the enlistment incentive provided by the changing benefit levels under the GI Bill and VEAP.

Unfortunately--and this turns out to be a rather serious "unfortunately"--computing present values requires that we make some assumptions. What I've done is to make a set of assumptions, compute a present value series covering the period from 1970 to 1980, and then try some alternative assumptions to see what happens to the series.

First, I had to decide what sort of enlistee to look at. With apologies to my Navy hosts, I chose someone entering the Army for a three year tour, beginning on the first of July of each year. He expects to begin college in the fall following his discharge, and to attend full time for four academic years, thus receiving 36 months of benefits. He is married and has one child.

For the rest of the assumptions it's harder to imagine a typical enlistee, so these are the ones I allowed to vary. The base case assumptions, against which I examined variations, were:

- o Inflationary expectations: the enlistee expects inflation to continue at its average rate during the two years prior to his enlistment.
- o GI Bill benefit increases: the enlistee expects benefits to be raised to keep pace with inflation.
- o Real discount rate (rate of time preference): 10 percent. That is, \$1.10 one year from today is now worth to the enlistee, ignoring price changes, \$1.00.

- o VEAP contribution rate: \$75 per month.
- o Eligibility for VEAP kicker: the enlistee qualifies for the VEAP kicker (\$3000 in 1979, \$4000 in 1980).

Figure 1 shows, with a solid line, the present value series that results from the base case assumptions. The changes in value within

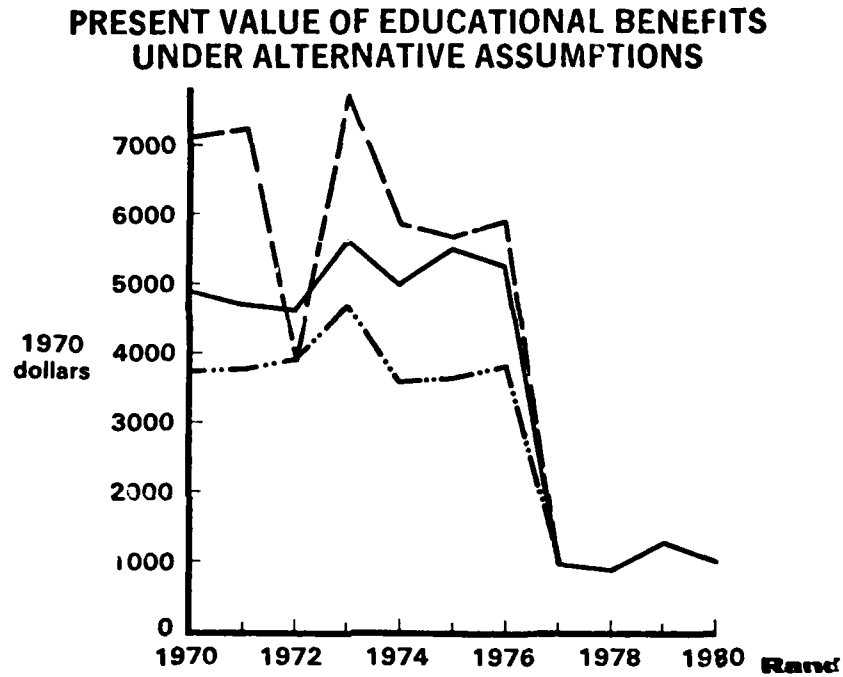


Fig. 1

programs were small compared with the reduction of more than 80% when the switch to VEAP took place. A comparison of undiscounted benefits would show only a 60% reduction. The other two lines show the effects of changing the assumption about GI Bill benefit levels: for the upper (dashed) line, I assumed that he expected benefits to increase at their average rate during the two years prior to his enlistment, and for the lower (dot-dash) that they would not increase. The dashed line shows much more variation than the base case because benefit increases were erratic.

In Figure 2, the base case is again the solid line, and I show some alternative assumptions that affect only the value of VEAP. The dashed line represents a monthly contribution at the minimum level of \$50, and the dot-dash line shows the value for an enlistee who does not get the kicker. The deviations from the base case look small in comparison to GI Bill levels, but viewed in isolation they are quite substantial.

Finally, Figure 3 illustrates two changes in assumption that affect the present value of both VEAP and the GI Bill. The dashed line is based on the assumption that the enlistee expects no inflation. For the dot-dash line I used a real discount rate of 25%; perhaps too high to be realistic, but it shows the very substantial effect that the discount rate has. Both these changes have substantial impacts on the relative magnitude of the reduction in 1976-1977. The no-inflation assumption reduces the decline to only 70%, while the higher discount rate increases it to more than 95% (both relative to the 1976 value of the GI Bill). If I had used a slightly higher discount rate, or plotted the case of no kicker, you could see an example of a negative present value for VEAP.

Unfortunately, it wasn't feasible to put all these series on one graph, but what one would see looking at them all is that in their basic pattern they look similar, but in terms of how big they make the 1976-1977 decline appear they are quite different.

With that as background, one can draw several conclusions.

1. If all that is desired is to control for changes in benefit levels and programs, any of these series can be used. They are all correlated with one another at the .98 level or higher, and so would be highly correlated with the "true" series.
2. It is not possible accurately to measure a response rate, or elasticity. We are either stuck with a very short time period if we look only at the GI Bill or VEAP, or we get an estimate that is dominated by one very big change. For that one change we don't know--even in relative terms--how big it was: the magnitude of the decline in present value depends upon the assumptions we make.
3. A simple zero/one dummy variable is just as useful as any of the present value series. All we can hope to do is control for the effect of the program change, and in any event a dummy variable is as highly correlated with each of the present value series as they are with one another.
4. Experimentation will be required if we are to have reliable estimates of the enlistment effect of changing the level of benefits available under VEAP, or of shifting to a more generous program. Time series analysis won't work: the time period for VEAP alone is too short, and any longer series is too unreliable.

PRESENT VALUE OF EDUCATIONAL BENEFITS UNDER ALTERNATIVE ASSUMPTIONS

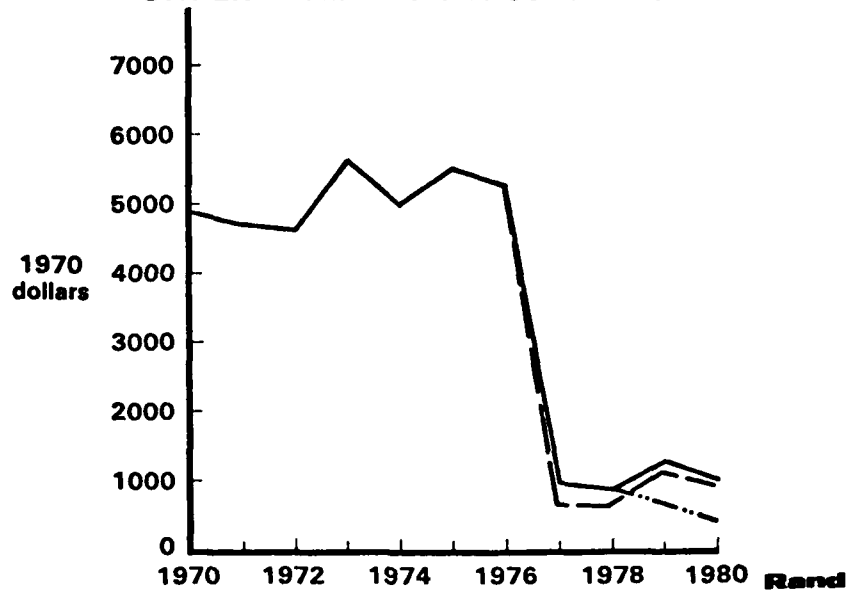


Fig. 2

PRESENT VALUE OF EDUCATIONAL BENEFITS UNDER ALTERNATIVE ASSUMPTIONS

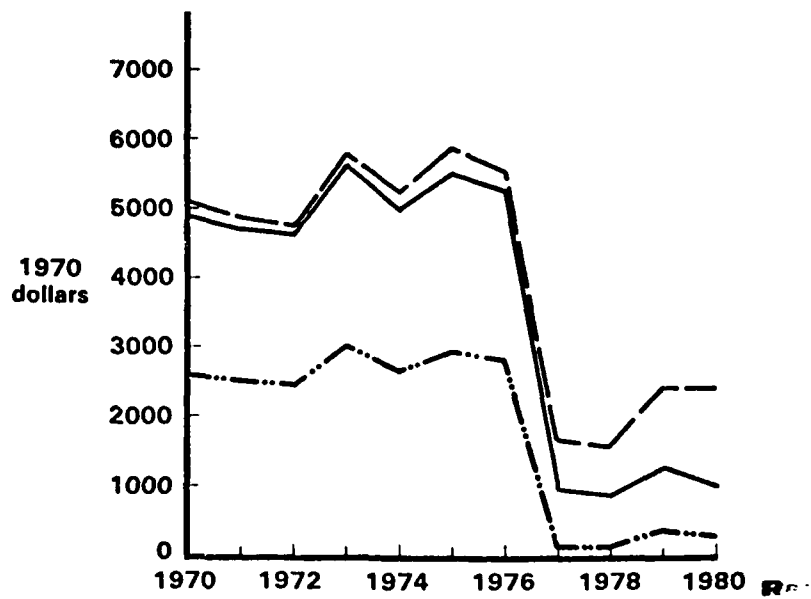


Fig. 3

We learned a little from the Multiple Option Recruiting Experiment of 1979, and hope to learn more from the Educational Assistance Test Program (EATP), which is being run this year and which will be analyzed by Rand. EATP is a test of four alternative programs, the features of which are summarized in Figure 4. All four programs are being offered

EDUCATIONAL BENEFITS TEST DESIGN

| Test cell | A | B | C | D |
|---------------------------------|---------------------------------|------------------------|-----|--------------------------------|
| Percent of market | 52 | 18 | 15 | 15 |
| Program features ^a : | | | | |
| VEAP | Yes | Yes | No | Yes |
| Kickers (Army only) | \$2,000, \$4,000, or \$6,000 | \$8,000 or \$12,000 | No | \$2,000, \$4,000 or \$6,000 |
| Tuition plus stipend | No | No | Yes | No |
| Contributory | Yes | Yes | No | No |
| Indexed | No | No | Yes | No |

^aFor qualifying enlistees. Others eligible for basic VEAP in all cells.

Fig. 4

Rand

only to high school diploma graduates who score in the top half on the AFQT and enlist in a "critical skill" as defined by each of the services. In the Army the eligible skills are primarily in the combat arms, but in the other services many of the skills require relatively high ability.

Each cell consists of a number of AFEEs areas. The cells were balanced on several criteria including local wage levels and unemployment, longitude and latitude, and enlistment rates. The three test programs were designed independently by the Army (Cell B), the House Armed Services Committee (Cell C), and the Senate Armed Services Committee (Cell D). Cell A, while not a true control cell, represents the status quo before the test began. The test began on 1 December 1980 (Cell B started on 1 October), and is scheduled to last 11 months.

EATP will not, unfortunately, answer all of the policy questions of interest about the enlistment effects of educational benefits. Because the programs differ in so many details it will not be possible, for example, to separate the effect of the more generous offering in Cell C than in the control cell, from the effect of its noncontributory or indexation features. We should learn something, however, about the possibility of substantially increasing enlistments of high quality youths by offering a significantly more generous program than what is currently available.

AN ECONOMETRIC MODEL OF ENLISTMENT BEHAVIOR

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INTRODUCTION

In recent years a number of studies have estimated the magnitudes in which various factors have influenced Navy enlistment behavior. With few exceptions, these studies utilize single equation regression techniques to relate the high quality enlistment rate to the number of recruiters, the ratio of civilian to military wages, the unemployment rate, and advertising expenditures. In these various efforts to investigate the determinants of enlistment supply, analysts have been hampered by enlistment data of relatively poor quality and by the general lack of information on the socioeconomic determinants of enlistment behavior. Whereas the influence of certain variables, such as the number of recruiters, appears with some consistency, the influence of other variables, such as advertising expenditures, are not consistent. One possible cause of the inconsistent findings is that the models and data used to estimate them have frequently been different. Another possible cause, however, is the failure to consider the effect of total requirements (goals) on the quantity and quality of enlistments.

In traditional labor economics, the supply of and demand for labor services are brought into balance through adjustments in the wage rate. In the military labor market, however, both the demand for labor services (goals) and the wage rate are fixed through congressional edict. Given the requirement to enlist so many individuals, the Navy Recruiting Command allocates the available recruiting resources so as to maximize the quality of its recruits.

The Navy specifies quality standards through the imposition of enlistment quality quotas. Enlistment quality quotas are specific targets or objectives expressed as percentages of total requirements which are to be a particular quality level. In FY 78, for example, the Navy established a seventy-six high school diploma graduate (HSDG) quota. The total requirement for non-prior service male enlistees to active duty was 79,089. Thus, at the national level, 60,107 HSDGs and 18,982 non-HSDGs were required.

The traditional assumption made in previous supply models is that there is an excess supply of low quality enlistees and an excess demand for high quality enlistees. There are reasons to believe, however, that the number of high quality enlistees is also influenced by recruiting requirements. As Goldberg (1979) has argued, recruiters may exert more effort when requirements are high. In addition, the Navy Recruiting Command allocates a fraction of the national requirement to each of the six Navy Recruiting Areas (NRAs) within the United States. The NRA Commander, in turn, further allocates his requirements to each Navy Recruiting District (NRD) within his area. Since these allocation procedures are imprecise, some NRDs may be "under-goaled" in the sense that more high quality recruits were available than were required. Hence, in NRDs which attained goal, recruiter productivity may have been limited.

It is important to note that the goals promulgated relate to enlistment accessions (shipments to bootcamp) and not to enlistment contracts. Thus, once their enlistment goal is attained, recruiters could presumably write Delayed Entry

Program (DEP) contracts for accessions in the next year. Thus, the appropriate specification of the dependent variable in enlistment supply models is contracts, not accessions. Nevertheless, because recruiters are limited in the number of DEP contracts they can offer, there may still be a relationship between goals, recruiter effort, and the number of HSDG contracts.

The Model

The enlistment contract rate (HSDG contracts divided by the number of high school seniors) was related via regression analysis to recruiters per high school senior, the unemployment rate, employment expectations, interest to join the Navy, and the ratio of civilian to military pay. The recruiter strength measure was defined as "factored canvassers," which are production recruiters weighted by time-on-board. The employment expectations variable, derived from the Youth Attitude Tracking Surveys (YATS), was specified as the percentage of respondents who indicated that employment was easy to obtain. Interest to join the Navy, also derived from YATS, was defined as the percentage of respondents who answered "definitely" or "probably" to a question regarding enlistment intentions to join the Navy.

Complete sets of observations were available by Navy Recruiting District for fiscal years 1977, 1978, and 1979. Exploratory analysis of the data revealed that the pooling of the time-series cross-section data was not appropriate. In particular, NRDs which did not attain their goal had uniformly different parameters than NRDs which did, supporting our previous discussion. Thus, we estimated separate cross-section equations for each fiscal year for those NRDs which failed to attain goal. These three equations were estimated jointly via Zellner's Seemingly Unrelated Regression technique. A functional form was estimated which exhibits both the properties of diminishing returns and complementary inputs. For example, the marginal productivity of an additional recruiter is likely to decline, particularly when the recruiting market is saturated. Moreover, recruiting productivity is likely to be related to supply conditions in the recruiting environment; recruiters will be more productive, for example, when the unemployment rate is comparatively high.

MODEL ESTIMATES

Based on the parameters of the models, the following elasticities were derived:

HSDG Elasticities

| | <u>1977</u> | <u>1978</u> | <u>1979</u> |
|-------------------------|-------------|-------------|-------------|
| Recruiters per Graduate | .89 | .75 | .83 |
| Civilian/Military Pay | -.43 | -.29 | -.26 |
| Interest | .02 | .12 | .11 |
| Employment Expectations | -.10 | 0 | .05 |
| Unemployment Rate | .12 | .13 | .08 |

Except for the unemployment expectations variable, the variables have the expected signs and are statistically significant at the 5% level or better. The recruiter elasticities of .75-.89 are somewhat higher than that found in many studies. However, one should be careful in interpreting results such as these for policy (quantitative) analyses. As with most enlistment supply models, multicollinearity is an acute problem. For example, the simple correlation between the number of recruiters and advertising expenditures is .83. When various advertising variables are included in the estimating equation, the coefficients are not statistically significant. Thus, in aggregate models of this nature, it is not possible to precisely estimate the separate effects of recruiters and advertising.

There is an additional problem in that the Navy Recruiting Command allocates the recruiting goal on the basis of many of the same variables in the model. For example, the simple correlation between recruiters and goals is .97. If our hypothesis regarding goals and recruiter effort is correct, then it is conceivable that some of the variables are capturing the effect of the goaling process. If this is true, then the elasticities found in cross-section supply models will be overstated.

In an effort to estimate the effects of other service competition, we have also included variables measuring Army, Air Force, and Marine Corp accessions in our estimating equation. Without exception, the signs associated with these variables are positive and statistically significant. We would expect a negative sign; the greater the number of enlistees to the other services, ceteris paribus, the fewer available to the Navy. Clearly these variables are not capturing the desired competition effect. Rather, since the recruiting environment is favorable to all of the services in a particular area, there is a positive relationship between Navy and other service enlistments.

The model was cross-validated with the following results:

HSDG MODEL VALIDATION

| | <u>1977</u> | <u>1978</u> | <u>1979</u> |
|----------|-------------|-------------|-------------|
| Actual | 75740 | 60995 | 57725 |
| Forecast | 71850 | 62396 | 54876 |
| % Error | -5.1% | +2.2% | -4.9% |

SUMMARY

In summary, models such as the one presented here provide policy-makers with general guidelines for resource allocation. Due to the multicollinearity problem, in particular the concomitant determination of recruiters, advertising, and goals, the parameter estimates are imprecise. Hence, regression models of this nature are not capable of analyzing the impacts of radical policy changes. However, for forecasting purposes, the model appears to be reasonably accurate.

NEW ANALYSIS OF NAVY ENLISTMENTS

Lawrence Goldberg
Center for Naval Analyses

This study uses regression analysis to analyze the supply of Navy enlistments. The regression model is estimated with annual pooled data from Navy recruiting districts in FY 1977-79. The results are used to (1) estimate the effects of supply factors, (2) explain supply fluctuations in FY 1978-80, and (3) forecast supply and shortfalls in the 1980s.

METHODOLOGY

We assume enlistment supply of nonprior service male high school graduates is affected by economic factors and recruiting resources. The economic factors analyzed include relative military pay, civilian unemployment, and federal youth programs. The recruiting resources analyzed are Navy recruiters, Navy advertising, and other services' recruiters.

The study is unique in analyzing the competing effects on enlistments of federal youth programs. Some programs, sponsored by the Department of Labor's Employment and Training Administration (ETA), provide pay and training for civilians. Others are sponsored by the Department of Education; these provide financial assistance for college and vocational students.

FINDINGS

Increases in unemployment, Navy recruiters, and national advertising expenditures increase enlistments, and increases in the earnings of civilians compared to enlistees reduce them. ETA programs have a negative effect on supply: high school graduates in the upper mental groups are affected most by ETA programs oriented toward youth; those in the lower mental groups are affected most by countercyclical ETA programs.

We find no evidence that other services' recruiters reduce Navy enlistments: Army and Marine Corps recruiters have no effect, while Air Force recruiters seem to have a positive effect. We also find no effects of student-aid programs and local advertising expenditures.

To test the stability of the model, it was separately estimated for FY 1977, FY 1978, and FY 1979. We found most

coefficients were stable. The model was used to forecast enlistments in FY 1980. It accurately forecasted the change in supply relative to the FY 1979 level. These results increase our confidence in estimates of the effects of supply factors.

Effects of Supply Factors

We calculated the elasticities of supply factors (see table 1). A one percent increase in civilian to military pay would

TABLE 1
ELASTICITIES OF SUPPLY FACTORS

| | RELATIVE WAGES (CIV MIL) | UNEM- PLOYMENT RATES | NAVY RECRUITERS | AIR FORCE RECRUITERS | ETA YOUTH | ETA COUNTER- CYCLICAL | ADVERTISING | |
|-----------------------|--------------------------------|----------------------------|--------------------|-------------------------|--------------------|-----------------------------|---------------|-------|
| | | | | | | | TV & RADIO | OTHER |
| HSG CONTRACTS | -1.02 | 0.43 | 0.49 | 0.30 | -0.02 ^a | -0.10 | 0.040 | 0.016 |
| 1-3A HSG CONTRACTS | -1.08 | 0.36 | 0.48 | 0.59 | -0.16 | 0.02 ^a | 0.035 | 0.014 |

^aNOT STATISTICALLY SIGNIFICANT

cause high school graduate enlistment contracts to fall by 1.02 percent; for unemployment, it would cause them to increase by 0.43 percent; for countercyclical ETA programs, it would cause them to fall by 0.10 percent.

The Navy can increase the supply of enlistments by increasing recruiters, national advertising, or military pay. The cost per high school graduate contract generated is lowest for national advertising: just \$700 for newspapers, print media, direct mail, etc., and \$1,900 for TV and radio. For recruiters the cost is \$3,600. The cost for a \$2,500 bonus is much greater - \$27,000. A bonus is so expensive because it is given to all high school graduate or all 1-3A high school graduate enlistees, not just the few extra we are trying to attract.

Supply Fluctuations in FY 1977-80

During FY 1977-79 there was a sharp decline in enlistments for all services. In FY 1980 enlistments increased DoD-wide. These supply fluctuations were caused by changes in relative pay, unemployment, and countercyclical ETA programs.

Forecasts of Supply and Shortfalls

The results were used to forecast high school graduate contracts in FY 1981-89 (see table 2). Unemployment is difficult

TABLE 2

GOALS AND SUPPLY OF HIGH SCHOOL GRADUATES^a

| <u>FISCAL YEAR</u> | <u>GOALS^b</u> | <u>HIGH UNEMPLOYMENT (7.3 PERCENT)</u> | <u>MEDIUM UNEMPLOYMENT (6.6 PERCENT)</u> | <u>LOW UNEMPLOYMENT (5.5 PERCENT)</u> |
|------------------------|--------------------------|--|--|---|
| 1980 (actuals) | 63,200 | 67,200 | N.A. | N.A. |
| 1981 | 65,000 | 72,500 | 69,800 | 65,100 |
| 1982 | 65,400 | 69,800 | 66,800 | 62,300 |
| 1983 | 62,900 | 66,900 | 63,900 | 59,500 |
| 1984 | 61,000 | 64,300 | 61,400 | 57,000 |
| 1985 | 61,300 | 62,500 | 59,600 | 55,100 |
| 1986 | 59,900 | 59,900 | 57,000 | 52,500 |
| 1987 | 59,900 | 58,700 | 55,800 | 51,400 |
| 1988 | 59,900 | 58,000 | 55,100 | 50,600 |
| 1989 | 59,900 | 57,600 | 54,600 | 50,200 |

^aThe standard error of a prediction for the regression period is 1600.

^bAssumes goal for high school graduates is 82 percent of the goal for nonprior service males. Other assumptions are: (1) in FY 1981, military pay increases by 5 percent more than civilian pay; (2) in FY 1982-89, military and civilian pay increase at the same rate; (3) starting in FY 1981, increases in standards reduce supply by only 2,000 per year; (4) the Navy Five Year Defense Plan (as of October 1980) is the basis for enlistment goals and levels of recruiting resources; (5) the enlistment goal in FY 1987-89 is fixed at the FY 1986 level; and (6) a change in population causes a proportional change in enlistments.

to predict, so forecasts are made for high, medium, and low unemployment rates. Population declines will cause contracts to decline in the 1980s. Sooner or later depending on the level of unemployment, enlistment goals will not be achieved. Given the medium unemployment rate, goal will not be achieved after 1984. It may not be achieved earlier if unemployment declines. Thus, there may be temporary shortfalls in FY 1982-84 and chronic shortfalls in FY 1985-89.

Shortfalls as large as 16 percent could occur by FY 1989. However, even these could be eliminated with just 10 percent increases in military pay and recruiting resources. The cost today would be about \$175 million if the increased military pay were given as bonuses.

Estimates of shortfalls assume that military pay keeps up with civilian pay. But previous experience indicates that increases in military pay have lagged behind increases in civilian pay. This could cause a serious problem when the unemployment rate falls to 5.5 percent as it did in FY 1978. Shortfalls would be about ten percent larger. Thus in FY 1989, there could be shortfalls of 26 percent.

CONCLUSIONS AND RECOMMENDATIONS

While the Navy faces serious shortfalls in the 1980s, they can be met by increasing recruiting resources and military pay. These remedies were used in meeting the temporary shortfalls of FY 1978-79, but the response was too slow: recruiters were not added until late in FY 1979; military pay was not raised until FY 1981.

The Navy must respond more quickly in dealing with temporary shortfalls. We recommend adjusting levels of military pay and recruiting resources to the level of supply. This could be done by (1) tying military pay to civilian earnings of youths on a year-to-year basis, and (2) adjusting recruiting resources to the unemployment rate and the level of ETA expenditures.

SUMMARY OF A VALIDATION EFFORT AND COST-EFFECTIVENESS ANALYSIS
FOR THE DUKE FORECASTING MODELS

Richard C. Morey
Duke University

The Duke analysis of 1980 developed two supply equations, one for all High School Graduate enlistments and one for bright High School Graduate enlistments; the latter group consists of those recruits scoring in Mental Categories I-III A on the Armed Forces entrance exam.

The predictive equations utilized were developed using data only from the period January 76 through December 78. This involved a pooled cross-sectional, time series data base consisting of 43 districts X 36 months or 1,548 cells of data. A log-lag model was used so the resulting coefficients are to be interpreted as elasticities; the Koyck distributed lag model was used to model the long term effects. A heteroscedastic regression technique was utilized which automatically adjusted for autocorrelations and unequal variances. A recursive two equation system resulted where national leads, a function of advertising and demographics, became a predictor of enlistments. No area or district dummies were used in the regressions since the Navy Recruiting Command was not interested in capturing differences in relative efficiency, but only differences due to demographics and differences in the levels of resources expended; monthly dummies were used to handle the strong seasonal nature of recruiting.

After verifying the reasonableness of the coefficients, in terms of the direction and magnitudes of the elasticities based on past studies and expert opinion, the equations were used to predict the monthly and geographical levels of enlistments for the independent period of January 1979-September 1979. The actual levels of advertising in the previous two months, the estimated length of the advertising lag, as well as the level of advertising for the month in question, were utilized in the equation. Other variables included the actual number of recruits present, together with key demographics such as the size of the high school senior population, the area's unemployment rate, the area's percent black, the area's urban-rural mix, and the ratio of military pay to civilian pay in the area.

Summaries of the monthly and regional forecasts, together with the actuals, follow in Table 1 for both HSG enlistments and bright HSG enlistments.

TABLE 1

DEGREE OF AGREEMENT BETWEEN PREDICTED
AND ACTUALS FOR THE INDEPENDENT
TIME PERIOD OF 1/79-9/79

| | <u>High School</u> <u>Graduate Enlistments</u> | | <u>Upper High School</u> <u>Graduate Enlistments</u> | |
|--|---|--------------------------------|---|------------------|
| | <u>Actual</u> | <u>Predicted (Error Rate*)</u> | <u>Actual</u> | <u>Predicted</u> |
| <u>NATIONAL ENTIRE</u> <u>9 MONTH PERIOD</u> | 45,137 | 43,459 (-3.7%) | 29,795 | 32,019 (+7.46%) |
| <u>Area, Entire 9 Month Period</u> | | | | |
| Area 100 | 9,667 | 9,102 | 6,383 | 6,979 |
| Area 300 | 8,582 | 8,446 | 5,073 | 5,424 |
| Area 400 | 8,409 | 8,321 | 5,503 | 6,038 |
| Area 500 | 4,986 | 5,055 | 3,595 | 3,758 |
| Area 700 | 5,592 | 5,531 | 3,668 | 3,795 |
| Area 800 | 7,901 | 7,004 | 5,573 | 6,026 |
| <u>MEAN</u> <u>ABSOLUTE</u> <u>ERROR RATE</u> <u>OVER ALL AREAS</u> | | 3.7% | | 7% |
| <u>NATIONAL, MONTHLY RESULTS</u> | | | | |
| January 1979 | 5,316 | 5,150 | 3,703 | 3,880 |
| February 1979 | 4,639 | 5,463 | 3,314 | 3,390 |
| March, 1979 | 4,931 | 5,519 | 3,418 | 3,682 |
| April, 1979 | 4,030 | 4,113 | 2,788 | 2,924 |
| May, 1979 | 4,007 | 3,772 | 2,703 | 2,918 |
| June, 1979 | 5,361 | 4,802 | 3,359 | 3,512 |
| July, 1979 | 5,416 | 4,951 | 3,588 | 3,603 |
| August, 1979 | 6,313 | 4,975 | 3,864 | 4,516 |
| September, 1979 | 5,124 | 4,715 | 3,054 | 3,538 |
| <u>MEAN ABSOLUTE</u> <u>ERROR RATE</u> <u>OVER ALL MONTHS</u> | | 9.87% | | 7.43% |

*All error rates are $\frac{\text{"Predicted"} - \text{"Actuals"}}{\text{"Actuals"}}$

Recall that no geographical dummies were used, so that difference in the forecast and actual may be due to real differences in the operating efficiencies among the districts. It might be pointed out in passing that a partial reason for the HSG enlistment forecaster to apparently outperform the Upper High School Graduate enlistment forecaster is the difference in the rigor of the data bases used. For HSG's, the data base for the period 1976-1978 had been collected by the Recruiting Command itself and was reasonably error-free. Unfortunately, the Recruiting Command had not been collecting its own data on upper HSG enlistments over this entire period; further, in spite of the fact that the Defense Manpower Data Center (DMDC) had data on both types of recruits, their HSG's did not agree with that of the Recruiting Command which were felt to be more reliable. Hence, the HSG enlistments from the Recruiting Command, together with DMDC's ratios of Upper HSG's to HSG, were used for the second forecaster. Hence, the lack of rigor for the data base for upper HSG's may be part of the reason for its poorer forecasts. These problems notwithstanding, it is felt the validation efforts were quite successful, both at the national, regional, and monthly level, and offer some real potential for aiding in the geographical allocation of recruiters and in the timing of advertising expenditures. The reader is referred to R. C. Morey and J. McCann's December '80' Management Science paper which discuss budget allocation models designed explicitly to utilize these types of response function.

Estimates of Elasticities and of Relative Cost-Effectiveness of Various Types of Recruiting Expenditures

Having established a degree of confidence in the estimating procedure, the equations were re-estimated using the entire 45 months of data, including the independent nine months held out for the validation effort. The

long term elasticities are shown in Table 2 for HSG contracts and Upper HSG contracts. Note that the really important controllable factors appear to be recruiters and local advertising.

TABLE 2
LONG TERM ELASTICITIES
BASED ON MONTHLY DISTRICT DATA
OVER PERIOD JANUARY 1976 - SEPTEMBER 1979

| Factor | All HSG Enlistments | Upper Mental HSG Enlistments |
|--|---------------------|---------------------------------|
| 1) No. of Bright High School male Seniors in area | N.A. | .0552 |
| 2) No. of High School male Seniors in area | .2398 | .2301 |
| 3) No. of Recruiters in area | .718 | .7406 |
| 4) Dollars of Local Advertising Impacting in area (constant dollars) | .0557 | .0604 |
| 5) Dollars of TV/Radio/ Billboards from CEP Budget Impacting in area (constant dollars) | .0051 | .0016 |
| 6) Dollars of Magazines Advertising Impacting Area (constant dollars) | .0067 | .0021 |
| 7) Dollars of Direct Mail Impacting Area (constant dollars) | .0032 | .001 |
| 8) Perception of Military in area | .6056 | .586 |
| 9) Percent Black in area | .0033 | -.061 |
| 10) Percent Urban/ Rural in area | .137 | .147 |
| 11) General Unemploy- ment Rate in area | .2552 | .1792 |
| 12) Ratio of Military Pay to Civilian Pay in area (average first year) | .1787 | .0254 |

Table 3 shows for HSG and Upper HSG enlistments, using the actual costs and levels of enlistment attained in FY 1979, the estimated marginal costs

TABLE 3

ESTIMATED MARGINAL COST PER ADDITIONAL
ENLISTMENT IN FY79 IF ADDITIONAL
DOLLARS SPENT IN ONLY ONE RESOURCE

| EXPENDITURE TYPE | LEVEL OF ACTUAL EXPENDITURES IN FY79 ⁺ | ESTIMATED LEVEL REQUIRED FOR 1 ADDITIONAL HSG ENLISTMENT | ESTIMATED LEVEL RE- QUIRED FOR 1 ADDITIONAL UPPER MENTAL HSG ENLISTMENT |
|---|--|--|--|
| 1) Recruiters and support materials | 3,405 man-years plus \$ 3.779 million in brochures, etc. | .0833 Recruiters man-years* | .1224 Recruiters man-years** |
| 2) Locally placed classified ads | \$ 1.024 million | \$ 323 | \$ 452 |
| 3) TV/Radio/ Billboards (Includes minorities advertising) | \$ 4.635 million | \$ 13,619 | \$ 65,765 |
| 4) Magazines and Supplements | \$.229 million | \$ 601 | \$ 2,903 |
| 5) Direct Mail | \$.235 million | \$ 1,291 | \$ 6,257 |

+ The advertising costs represent only the actual placement cost of the advertising and do not include copy costs, overhead or profits of the ad agencies.

* This represents \$1,766 to \$ 2,582, depending on the types of cost included. At the margin this is equivalent to an added recruiter, attaining an additional 11.998 HSG enlistments per year, when the actual average was 16.71.

** This cost is \$ 2,594 to \$ 3,794. At the margin an additional recruiter would be estimated to add another 8.17 upper mental HSG enlistment per year, the average in FY79 being 11.03.

to obtain an additional contract of each type if all the additional funds were expended on only one type of resource; the other levels would be assumed to have been held constant. Hence, while the elasticities utilized are based on the 45 months of data, the level of contracts and level of resources utilized for FY79.

Note that local advertising seems to be by far the most cost-effective mechanism with recruiters and magazines as second choices. Advertising in the local classified ads, while it does not appear to have any impact on national leads, does appear to generate visits to the local recruiting stations. Its main advantages are that it is relatively inexpensive and impacts the reader when he is very motivated to find employment. Also note the diminishing returns operating where an additional recruiter could be expected to add only about eight bright HSG enlistments per year compared to the 11 bright enlistments each recruiter averaged in FY79.

ECONOMETRIC STUDY OF THE EFFECTIVENESS
OF U.S. NAVY RECRUITING*

Dominique M. Hanssens
University of California, Los Angeles

The process underlying volunteer Navy enlistments is complex, involving various environmental and marketing forces. We have made an attempt to quantify that process by combining Navy Recruiting Command's insights, elements of economics and marketing, and historical data analysis. Econometric models of recruiting performance, as measured by lead rates, DEP and DSHIP contract rates, were developed and estimated. The explanatory variables included several environmental factors, such as unemployment rate and youth attitude toward the Navy, and marketing efforts in the areas of advertising and personal selling.

The econometric models produced a number of substantive findings which can be integrated - though not perfectly - along three dimensions: (1) the relative impact of environmental vs. marketing variables on recruiting performance, (2) differences in response structure for the various criterion variables and (3) the relative effectiveness of media advertising and personal selling.

Overall, changes in the environment have a more drastic impact on recruiting performance than changes in marketing efforts. For example, the national average advertising/sales ratio (total media advertising divided by total contracts) was \$41 in 1976, \$76 in 1977 and \$96 in 1978. During that period, unemployment declined from 7.2 to 6.2% to 5.7% and the total numbers of contracts written were about 74,000, 83,000 and 68,000. These figures

*Editors' note: This article is Professor Hanssens's remarks also appears as the concluding statement in his paper, "An Econometric Study of Recruitment in the U.S. Navy," with Henry A. Levien, April 1981 (submitted elsewhere for publication).

illustrate that increased marketing spending does not stimulate recruiting performance when the environment becomes more difficult (e.g. the unemployment rate declines). At the district level, differences in youth attitudes toward the Navy, degree of urbanization, proportion of high-school seniors and blacks in the target market are primarily responsible for the variability in recruiting performance across NRD's, in spite of the fact that the poorly performing NRD's have received more recruiters, local advertising and recruiter aid support on a per capita basis.

It is difficult to compare this substantive finding to others in the literature, because few empirical macro-marketing studies have included many environmental explanatory variables. As far as advertising is concerned, the result is in line with "Finding 5" of Lambin's exhaustive empirical investigation, which states that "the impact of advertising is modest in comparison with that of environmental factors and other marketing variables."

The second area of substantive conclusions is a comparison of the response functions for leads and contracts. Number of leads as a criterion variable implies a lower behavioral commitment than number of accession contracts. In this light, it is not counterintuitive to find that leads are more sensitive to changes in the environmental and marketing variables (e.g. advertising) than contracts. On the other hand, word-of-mouth effects are more pronounced for contracts than for leads, or, low (high) behavioral commitment is associated more with impersonal (personal) communication sources.

Perhaps the richest findings are in the area of advertising and personal selling. One unique aspect of this study was the presence of quantitative and

* Lambin, J. J. (1976), Advertising, Competition and Market Conduct in Oligopoly Over Time, Amsterdam: North-Holland, p. 101.

motivational data on personal selling, i.e. recruiter strength and direct-shipment requirement. The models indicate that, when motivation is most important (i.e. for the direct-shipment contracts), changes in the sales force size have no noticeable impact on performance. However, for the "unconstrained" DEP contracts, it is recruiter strength which has the higher elasticity.

On the advertising side, the results confirm one aspect of the hierarchy-of-effects hypothesis in that the elasticity for leads ("interest") is higher than for contracts ("purchase"). More importantly, the leads model provides evidence of advertising wearout effects. To the best of the authors' knowledge, this study is the first to investigate wearout effects in multiple media. The fact that the differential stimulus elasticities are different and not always significant raises some theoretical questions such as "is there a relationship between the newness of a medium and wearout" and "is there a negative relationship between advertising main effects and wearout?"

In comparison to the existing literature, this study has introduced a large number of new variables with a hypothesized impact on recruiting performance. There are, however, some limitations: the effects of locally generated leads on contracts remain unexplored, for lack of data. Also, some potentially important breakdowns of accession contracts, such as high school vs. other contracts or high vs. lower aptitude recruits, were not available. It is hoped that further research will have access to these data, for the benefit of our understanding of the volunteer enlistment process.

Appendix A

WORKSHOP ON PERSONNEL SUPPLY MODELS
sponsored by
The Office of Naval Research, the Deputy Assistant Secretary of the Navy
(Manpower), and the Navy Recruiting Command

Marriott Key Bridge Hotel
Arlington, Virginia

22-23 January 1981
8:30 a.m. - 4:45 p.m.

AGENDA

January 22 - LCOL J. A. Cirie, USMC, Office of the Deputy ASN (Manpower),
Chairman

- 8:30 Welcome - Mary Snavely-Dixon, Deputy ASN (Manpower)
- 8:45 Review of models (I) - Frank Bass, Krannert Graduate School of Management, Purdue University
- 10:15 Coffee break
- 10:45 Review of models (II) - Robert Oliver, Operations Research Center, University of California, Berkeley
- 12:15 Lunch break
- 1:45 Review of models (III) - N. Keith Womer, Department of Industrial Management, Clemson University
- 3:15 Coffee break
- 3:45 Measuring the effects of policy change - Richard Fernandez, Rand
- 4:15 Measuring accessions vs. measuring supply: The difference - Barry Siegel, Navy Personnel R&D Center
- 4:45 Adjourn

January 23 - Glenn L. Bryan, Director, Psychological Sciences Division, ONR,
Chairman

- 8:30 New analysis of Navy enlistments - Lawrence Goldberg, Center for Naval Analyses
- 9:15 Validation of the Duke forecasting model: Some insights into the relative cost effectiveness of recruiting expenditures - Richard Morey, Graduate School of Business Administration, Duke University
- 10:00 Coffee break
- 10:30 Recap and review

January 23, continued:

- 1:00 *Econometric study of the effectiveness of U.S. Navy recruiting* -
Dominique Hanssens, Graduate School of Management, UCLA
- 1:45 Recruiting resource allocation experiment - Vincent Carroll,
Wharton Applied Research Center, University of Pennsylvania
- 2:30 Wrap-up
- 3:30 Adjourn

Appendix B

WORKSHOP ON PERSONNEL SUPPLY MODELS

Marriott Key Bridge Hotel

22-23 January 1981

ROSTER

Professor Frank Bass
Purdue University

Dr. Glenn L. Bryan
Office of Naval Research

MAJ T. V. Burns, USMC
U. S. Marine Corps HQ (MPI-20)

Mr. Vincent Carroll
University of Pennsylvania

LCOL J. A. Cirie, USMC
Office of the Deputy ASN (Manpower)

Dr. Richard Fernandez
The Rand Corporation

LCDR J. M. Green, USN
Office of the CNO (Op-110)

Dr. Lawrence Goldberg
Center for Naval Analyses (INS)

Dr. David Grissmer
The Rand Corporation

Professor Dominique Hanssens
UCLA

Mr. Paul Hogan
Office of the ASD (MRA&L)

CAPT J. A. Hoskins, USAF
AF Manpower & Personnel (MPXA)

Mr. Ron Liveris
Offices of the ASD (MRA&L)

Dr. Kneale Marshall
Naval Postgraduate School

Mr. J. J. Miller
Navy Recruiting Command

Dr. Richard C. Morey
Duke University

Professor Robert M. Oliver
U. of California, Berkeley

LtCOL D. A. Patterson, USAF
AF Manpower & Personnel (MPXO)

Dr. Ambar Rao
OR/MS Dialogue

Mr. Arnold Rubinstein
Naval Material Command HQ

Mr. Barry Siegel
Navy Personnel R&D Center

Dr. G. Thomas Silicia
Office of the ASD (MRA&L)

Dr. William Sims
Center for Naval Analyses (MCOAG)

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